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Utah Bat Conservation Plan

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by

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Executive summary

There is conservational concern for nearly all bats. Great declines have been observed in some populations of even the most widespread and abundant bat species in America. Of the bat species that inhabit Utah, six are on the Utah Division of Wildlife Resources' state Sensitive Species List (tier II of the Utah Comprehensive Wildlife Conservation Strategy, CWCS), one other species is in tier III of CWCS, and several were former Category 2 candidates for federal listing by the U. S. Fish and Wildlife Service as threatened or endangered, under provisions of the Endangered Species Act, until Category 2 was eliminated in 1996.

The biology and life histories of most of the bat species that occur in Utah remain poorly and incompletely known, and this lack of knowledge impedes effective efforts to manage and to conserve their populations. Protection of roosting habitats, foraging habitats, and water are obvious conservational needs. To guide appropriate management, improved knowledge of the distributions (geographic inventory) and populations (monitoring of population trends) of the bat species that inhabit Utah is needed. To acquire the understanding needed for informed management, inventory and monitoring must be undertaken and accomplished in a systematic way.

This plan provides an overview of the bats of Utah, it summarizes threats to bats in Utah, it recommends needed actions, and it provides tools and informational resources that can be used to carry out the needed actions.

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Purpose

The purpose of this document is (1) to identify deficiencies in the understanding of the biology of the bats that inhabit Utah, (2) to identify anthropogenic threats to the bats of this state, (3) to direct research efforts to acquire needed knowledge, and (4) thus to guide management of Utah's bat species to ensure the viability of bat populations in the state. It is intended not to be static but instead to be a

dynamic or a “living” document that will be updated and expanded in future editions.

General overview of the biology of Utah bats

Utah’s known bat fauna comprises 18 species (Hasenyager 1980, Oliver 2000) or perhaps 19 or 20 species, depending on differing taxonomic opinions (“splitting”). Three additional species have been reported from Utah based on misidentification or presumption (see Oliver 2000), but some or all of these three species, and perhaps even others, may eventually be found in the state.

Being volant, bats, like birds, are among the most vagile of all organisms, and many species make long-distance seasonal migrations. Their great vagility facilitates their colonization of new areas and the expansion of their geographic ranges. It also predisposes them to wandering, and it makes them susceptible to passive dispersal by windstorms. Thus bats can quickly reach and exploit new suitable sites that have been artificially created, such as water sources (e.g., livestock tanks), roosts (e.g., buildings, mines, bridges), and altered landscapes (e.g., urban parks, orchards, pastures). Species of bats also sometimes appear in surprisingly unexpected places as “occasional”, “accidental”, or “vagrant” occurrences, which are temporary (i.e., not resulting in colonization, reproduction, and establishment of a local population). Thus the known bat fauna of an area, like its avifauna, not only can change more rapidly than that of non-volant animals but also can at times include unpredicted, accidental species. As a result, the documented bat fauna of Utah is expected to be less static or fixed than is the rest of Utah’s mammalian fauna.

All of the bat species known to occur in Utah, and all but one of the species that may yet be found to occur in the state, belong to two families, Vespertilionidae (vesper bats), which are cosmopolitan, and Molossidae (free-tailed bats), which are mostly pantropical but extend into subtropical and milder parts of temperate latitudes. The one species not known from Utah but of possible occurrence in the state that is not a member of these two families belongs to the family Phyllostomidae (New World leaf-nosed bats), which are neotropical, with a few species ranging into subtropical parts of the New World.

All of the bats that inhabit or potentially inhabit Utah are nocturnal, although a few are also crepuscular. All of the bats that occur or may occur in Utah are insectivorous, most of them strictly so, though at least one consumes some non-insect arthropods, and a few occasionally take vertebrate prey (including other bats). Some Utah bats capture prey in the air, some glean prey from foliage, some glean from rock surfaces, and at least one Utah species often alights on the ground, where it captures prey in terrestrial, quadrupedal fashion. Most Utah bats eat mainly moths, though a few species feed heavily on beetles. Despite

frequent claims that bats control mosquitoes, mosquitoes are not an important component of the diet of most bat species in Utah or elsewhere in America.

Some of Utah's bats migrate south out of the state for the winter; others hibernate in Utah, though they may be facultatively active during warmer periods, especially at the lowest latitudes and lowest elevations in the state (e.g., southern Washington County).

Roosts are of critical importance to bats, and different roosting situations may be used for different purposes. Roosts are of four general types: (1) diurnal roosts, (2) nocturnal roosts, (3) maternity roosts, and (4) hibernacula. Some species use a single roost for all of these purposes; others require as many as four roosts with very different physical and structural characteristics. Roosting situations used by different bat species in Utah include caves, mines, buildings, rock crevices, foliage, and crevices, hollows, and spaces under exfoliating bark of trees. It has even been speculated that one species that occurs in Utah may roost in burrows of rodents such as those of kangaroo rats. Some Utah bats roost in groups of various sizes, but other species roost singly, almost never being found with others except their own dependent young. Most Utah bats bear single young, but four species typically bear twins, and one species usually produces even larger litters. Only one litter is produced each year. This, together with small litter size, makes the reproductive potential of bats quite low relative to other small mammals. However, bats are much longer lived than most mammals of comparable size, individuals of some Utah species living 40 years or more.

Drinking water is of critical importance to most bats in Utah. Drinking is mostly is accomplished by skimming the water surface with open mandible (jaw). Surface waters also provide rich foraging sites since flying insects are often abundant over even small bodies of water, and surface water often is bordered or surrounded by more luxuriant vegetation that favors insect abundance.

Essentially all habitats that are present in Utah are utilized by bats. Only alpine tundra, vast, sparsely vegetated salt flats, and large hypersaline water bodies (e.g., interior portions of the Great Salt Lake) can be considered marginal or unsuitable habitats for bats in this state. Some Utah bat species are highly selective in their use of habitats, while others utilize a very broad range of habitats. A few species appear to be favored by certain human alterations of the landscape (e.g., livestock tanks and other artificial water sources, mines, buildings, and even cities), but others are affected only negatively by human alterations of the natural environment.

Their ecological requirements (suitable habitats that provide water, insect prey, and particular roost conditions) together with their life history characteristics (low reproductive rate and long life) make Utah's bats especially vulnerable to mortality and population reduction resulting directly or indirectly from many

human activities including the use of insecticides, water pollution, timber harvest and forest management, wind turbine energy production, abandoned mine closures, alterations of riparian habitats, and persecution and disturbance at roosts.

As a group, bats are arguably the most widely distributed of non-marine mammals. As discussed above, being volant, they are not limited by most of the barriers that impede dispersal and colonization by other mammalian groups. In terms of living species, the order Chiroptera (bats) is the second largest order of mammals, surpassed only by the order Rodentia (rodents). Despite their diversity, abundance, and worldwide distribution (except for Antarctica and the highest northern latitudes), bats are, as a group, perhaps the most poorly known of living mammals. Most of what is known of their biology has been learned since ca. 1960. The use of mist nets for the capture of bats revolutionized their study, and further technological advances continue to expand possibilities in bat research. Despite the much greater understanding of bats that has been achieved in recent decades, much remains to be learned. Various aspects of the basic biology of many common and widely occurring species are still unknown, including several species that are very common in Utah and western North America.

Detailed review and discussion of the biology of bat species in Utah has been provided by Hasenyager (1980) and Oliver (2000). Except for information reported after early 2000, those two sources summarize, in their accounts of species, practically all that is known about bats in this state, and they provide extensive lists of references to pertinent literature. Only minimal repetition of such information is made here (e.g., summaries below, mostly from Oliver 2000), and it is recommended that those reports be used in conjunction with this conservation plan.

The ecological requirements of the 19 bat species known to occur in Utah are presented in tabular form in 19 “ecological integrity tables” in Appendix 1 (Oliver). The concept and the form of ecological integrity tables were developed in 2004 by The Nature Conservancy (TNC).

There are several intended uses of the tables by UDWR. Most of UDWR's intended uses involve rapid assessment of sites when long-term, labor-intensive, expensive surveys, monitoring, and other studies are not options. UDWR's intended uses include:

(1) to estimate the ecological quality or suitability of a site for a particular species that we know inhabits the site, relative to other inhabited sites,

(2) to estimate the ecological value of a site for a particular species when we don't know whether it is present (i.e., to predict the species’ presence or absence

and the potential value of the site to the species if it is likely present), this use being especially important for extremely hard-to-detect species,

(3) to determine whether there are actions that can be taken that can be expected to make the site more suitable or actions that should be avoided in order to prevent the site from becoming unsuitable for the species (e.g., management actions, habitat manipulations or treatments),

(4) to evaluate the suitability of potential translocation and reintroduction sites, and

(5) to guide restoration projects intended to create or re-create suitable habitats and conditions meeting all of the life history requirements and ecological needs of a particular species.

Bat species known to occur in Utah

Various English common names exist for some bat species in Utah, and differing taxonomic opinions result in different scientific names for some Utah species as well. Common and scientific names used here mostly follow the "Texas Tech mammal checklist", i.e., Baker et al. (2003), which is the ninth version of the list (over the 30-year period 1973–2003). Nomenclatural changes pertaining to bats have been seen in most if not all editions of the Texas Tech list, and changes in the names of species occurring in Utah can be expected in its future editions. Although the list is widely followed by mammalogists in America and Canada and is intended to standardize mammal nomenclature, no one is required to follow it. Thus other common and scientific names have been used in the past, others will likely be used in the future, and even others are in current use by various authors who disagree with the current edition of the list. (See Oliver 2000 for discussions of formerly used common and scientific names, taxonomic debates and uncertainties, and nomenclatural stability or instability.) The genus *Parastrellus* (Hoofer et al. 2006) is used in the body text of this document (but not in all of the appendices) for the western pipistrelle; it is expected that this name will be endorsed by future editions of the Texas Tech mammal list.

The first 17 species listed below are members of the family Vespertilionidae; the last two species belong to the family Molossidae. The summaries below are strictly Utah-specific, except for number of young and main prey. In the category "main prey" in the synopses below, the generalized data are *not* from Utah, and the term "flies" has been used very loosely to include not only dipterans, the true flies (such as crane flies), but also various other small flying insects such as caddisflies and mayflies. To the extent that a generalization concerning the collective food habits of all Utah bats can be made, moths are overwhelming the most important foods for Utah bats, followed by beetles. Despite popular misunderstanding, mosquitoes are *not* important prey of bats in Utah or in

America, and bats in Utah do not play an important role in controlling mosquito populations (as discussed later in this document).

***Myotis lucifugus*, little brown myotis**

- Utah distribution: possibly all, but unreported from parts of northwestern, southwestern, and south-central Utah
- Utah wintering habits: unknown (hibernates and makes short-distance migratory movements elsewhere)
- Utah abundance: common (abundant in northern Utah)
- Utah diurnal roosts: attics, rock crevices
- Utah maternity roosts: attics, bridges
- Utah habitats: highland riparian areas, aspen forests, mixed forests, coniferous forests, cities and towns
- Utah elevational range: 4,300 to 10,000 ft
- number of young: 1
- main prey: “flies” (especially emerging aquatic flying insects), moths

***Myotis occultus*, Arizona myotis**

This putative species had not been reported in Utah until very recently, after the works by Hasenyager (1980) and Oliver (2000). However, Oliver (2000, p 7) mentioned its occurrence, as a race of *M. lucifugus*, very near several parts of southern Utah and briefly reviewed the long-standing debate of its taxonomic status as either a race of *M. lucifugus* or a full species. More recent work (Piaggio et al. 2002) has again argued for specific status, and the prevailing view currently is that it should be treated as a full species (Baker et al. 2003). E. W. Valdez (personal communication, 2003) and M. Siders (personal communication, 2005) have reported recent capture of this taxon in south-central Utah. Hoffmeister (1986), during a time when few mammalogists recognized the taxon as a full species, provided a useful account of *occultus*. Because *M. occultus* has only recently again become widely accepted as a species distinct from *M. lucifugus*, it would likely have been called *M. lucifugus* in Utah studies prior to 2002 or 2003, and nothing has been reported concerning its biology in Utah. Reports, if any, of *M. lucifugus* from extreme southern Utah before 2002 or 2003 may pertain to this species, although some such reports could be misidentifications of *M. yumanensis*.

***Myotis yumanensis*, Yuma myotis**

- Utah distribution: all except the northwest corner and extreme north-central; possibly statewide; few records in west and central
- Utah wintering habits: unknown

- Utah abundance: uncommon (fairly common in some places in south, rare elsewhere)
- Utah diurnal roosts: mines, buildings
- Utah maternity roosts: attics
- Utah habitats: lowland riparian and desert scrub to montane forest
- Utah elevational range: ≤2,800 to 10,098 ft
- number of young: 1
- main prey: moths, “flies”

Myotis evotis, long-eared myotis

- Utah distribution: statewide
- Utah wintering habits: unknown
- Utah abundance: common
- Utah diurnal roosts: buildings, caves
- Utah maternity roosts: unknown
- Utah habitats: lowland riparian and sagebrush to montane forest
- Utah elevational range: 4,700 to 9,500 ft (also 2,800 ft, perhaps aberrant)
- number of young: 1
- main prey: moths, beetles

Myotis thysanodes, fringed myotis

- Utah distribution: possibly statewide, but no records from northwest and most of west, few and scattered in central and northeast
- Utah wintering habits: unknown
- Utah abundance: uncommon
- Utah diurnal roosts: unknown
- Utah maternity roosts: attics of abandoned buildings, possibly caves
- Utah habitats: many, from lowland riparian and desert scrub to montane forest and meadows
- Utah elevational range: 2,400 to 8,900 ft
- number of young: 1
- main prey: beetles, moths

Myotis volans, long-legged myotis

- Utah distribution: statewide
- Utah wintering habits: unknown (but there are suggestions of possible migration and possible hibernation)
- Utah abundance: abundant
- Utah diurnal roosts: unknown

- Utah maternity roosts: unknown
- Utah habitats: lowland riparian and desert scrub to montane coniferous forest
- Utah elevational range: 3,150 to >10,000 ft
- number of young: 1
- main prey: moths

***Myotis californicus*, California myotis**

- Utah distribution: most of state except Uinta Mountains of northeast; no records from extreme north-central, northwest, and mountains of central
- Utah wintering habits: hibernates in mines and is active in winter in southwest; unknown in other parts of state
- Utah abundance: common
- Utah diurnal roosts: unknown
- Utah maternity roosts: unknown
- Utah habitats: cities, towns, ranches, and lowland riparian and desert scrub to montane mixed forest
- Utah elevational range: ≤2,600 to 9,000 ft
- number of young: 1
- main prey: "flies", moths

***Myotis ciliolabrum*, western small-footed myotis**

- Utah distribution: statewide
- Utah wintering habits: hibernates in caves and mines
- Utah abundance: uncommon
- Utah diurnal roosts: unknown
- Utah maternity roosts: unknown
- Utah habitats: lowland riparian and desert scrub to montane forest
- Utah night roosts: mines
- Utah elevational range: 2,950 to 8,900 ft
- number of young: 1
- main prey: moths, beetles

***Lasiurus blossevillii*, western red bat**

- Utah distribution: north–south band from extreme north-central to extreme southwest
- Utah wintering habits: unknown (may migrate)
- Utah abundance: very rare
- Utah diurnal roosts: a mine

- Utah maternity roosts: a cave
- Utah habitats: towns, cottonwood groves in lowland riparian areas
- Utah elevational range: 2,650 to 6,760 ft
- number of young: (2–)3
- main prey: moths, beetles

Lasiurus cinereus, hoary bat

- Utah distribution: statewide
- Utah wintering habits: presumably migrates; possibly overwinters in southwest
- Utah abundance: uncommon
- Utah diurnal roosts: a tree
- Utah maternity roosts: unknown
- Utah habitats: lowland riparian and desert scrub to montane forest; towns, cities
- Utah elevational range: ~2,500 to 9,200 ft
- number of young: 2
- main prey: moths

Lasionycteris noctivagans, silver-haired bat

- Utah distribution: statewide
- Utah wintering habits: presumed to migrate, but known to remain in winter in southwest
- Utah abundance: common
- Utah diurnal roosts: unknown
- Utah maternity roosts: unknown
- Utah habitats: lowland riparian and desert scrub to montane forest; also urban areas
- Utah elevational range: ~2,500 to 9,670 ft
- number of young: (1–)2
- main prey: “flies”, beetles, moths

Parastrellus hesperus, western pipistrelle

- Utah distribution: nearly statewide, but no records from extreme north-central and northwest and from Uinta Mountains, Wasatch Mountains, and mountains of Central High Plateaus
- Utah wintering habits: known to be active in winter in southwest; presumed to hibernate, but no records
- Utah abundance: extremely abundant

- Utah diurnal roosts: under rocks
- Utah maternity roosts: unknown
- Utah habitats: especially lowland riparian and desert scrub, but also sagebrush, juniper, piñon, mountain brush, mountain meadow; ranch and farmland
- Utah elevational range: $\leq$2,500 to $\geq$8,710 ft
- number of young: 2
- main prey: moths, leafhoppers, flying ants

Eptesicus fuscus, big brown bat

- Utah distribution: statewide
- Utah wintering habits: hibernates in caves and mines
- Utah abundance: abundant
- Utah diurnal roosts: a mine
- Utah maternity roosts: buildings (e.g., attics)
- Utah habitats: desert scrub to montane forest; cities, towns
- Utah elevational range: $\leq$2,500 to $\geq$8,600 ft
- number of young: 2
- main prey: beetles

Euderma maculatum, spotted bat

- Utah distribution: probably statewide, but records lacking from west (except southwest) and extreme north
- Utah wintering habits: hibernates in caves and is active during winter in southwest
- Utah abundance: rare
- Utah diurnal roosts: unknown
- Utah maternity roosts: unknown
- Utah habitats: lowland riparian and desert scrub to montane coniferous forest
- Utah elevational range: 2,700 to 9,200 ft
- number of young: 1
- main prey: moths

Idionycteris phyllotis, Allen's big-eared bat

- Utah distribution: south and southeast
- Utah wintering habits: unknown
- Utah abundance: rare
- Utah diurnal roosts: unknown

- Utah maternity roosts: unknown
- Utah habitats: lowland riparian and desert scrub to mountain brush and mixed forest
- Utah elevational range: ~2,500 to ≥7,860 ft
- number of young: 1
- main prey: moths

***Corynorhinus townsendii*, Townsend's big-eared bat**

- Utah distribution: statewide
- Utah wintering habits: hibernates in caves and mines
- Utah abundance: common
- Utah diurnal (and nocturnal) roosts: caves, abandoned mines, buildings
- Utah maternity roosts: caves, abandoned mines, buildings
- Utah habitats: desert scrub to montane forest
- Utah elevational range: 3,300 to ≥8,851 ft
- number of young: 1
- main prey: moths

***Antrozous pallidus*, pallid bat**

- Utah distribution: possibly statewide, but no records in most of north-central and northwest or in Wasatch and Uinta mountains and mountains of the Central High Plateaus
- Utah wintering habits: hibernates in caves; active in winter in southwest
- Utah abundance: common (at lower, drier sites)
- Utah diurnal roosts: unknown
- Utah maternity roosts: unknown
- Utah habitats: lowland riparian and desert scrub to mountain meadows; towns
- Utah elevational range: 2,700 to ≥8,700 ft
- number of young: 2
- main prey: various insects, non-insect terrestrial arthropods

***Tadarida brasiliensis*, Brazilian free-tailed bat**

- Utah distribution: possibly statewide, except perhaps for the northernmost counties
- Utah wintering habits: some populations migrate, some (southwest) remain and are active at times, even in freezing weather, some presumably hibernate
- Utah abundance: abundant

- Utah diurnal roosts: buildings, rock crevices
- Utah maternity roosts: attics of buildings
- Utah habitats: lowland riparian and desert scrub to ponderosa pine forest; cities and towns
- Utah elevational range: ≤2,600 to ≥8,000 ft
- number of young: 1
- main prey: moths

***Nyctinomops macrotis*, big free-tailed bat**

- Utah distribution: southern half of state, perhaps north to the Wyoming border in the east
- Utah wintering habits: unknown, presumed to migrate
- Utah abundance: rare (but may be fairly common in some places)
- Utah diurnal roosts: unknown
- Utah maternity roosts: unknown
- Utah habitats: lowland riparian, desert scrub, montane forest
- Utah elevational range: ≤2,700 to 9,200 ft
- number of young: 1
- main prey: moths

Conservational status of Utah bats

The Western Bat Working Group (WBWG) produced (1998) a "Regional Bat Species Priority Matrix" of imperilment and thus priority for funding, planning, and conservation actions. Three levels of priority—high, medium, and low—and one other classification (peripheral) were assigned to species in each of up to six regions in western North America based on 10 of Bailey's (U. S. Forest Service) ecoregions of the United States. Four of the possible six regions are represented in Utah. The following adaptation (under column headed "WBWG") summarizes these conservational classifications, by bat species, within the four ecoregions that are present in Utah. "High" represents the greatest level of conservational concern. For some species, combining the four regional ranks into a single assessment for Utah is problematical, and a second possibility is given in parentheses. "High" means the species is "considered the highest priority for funding, planning, and conservation actions" and is "imperiled or at high risk of imperilment"; "medium" "indicates a level of concern that should warrant closer evaluation, more research, and conservation actions of both the species and possible threats"; and "low" means that, "[w]hile there may be localized concerns, the overall status of the species is believed to be secure" (WBWG 1998).

The Utah Division of Wildlife Resources, in its Comprehensive Wildlife Conservation Strategy (CWCS) (Sutter et al. 2005), assigned Utah animal species of conservational concern to three tiers. Tier I contains species that are federally listed, candidate, or conservation agreement species; there are no bats in Utah with special federal status (i.e., none in tier I). Tier II contains species identified by UDWR as Utah Species of Concern in the Utah Sensitive Species List (UDWR 2005). Tier III contains species for which there may be conservational concern and (usually) for which there is a lack of information adequate to assess their status in Utah. In the list below (under column headed "UDWR"), bat species that are in neither tier II nor tier III are indicated with a dash (—).

species	**WBWG**	**UDWR**
Myotis lucifugus, little brown myotis	low	—
Myotis occultus, Arizona myotis	medium	—
Myotis yumanensis, Yuma myotis	medium, (low)	III
Myotis evotis, long-eared myotis	medium	—
Myotis thysanodes, fringed myotis	medium, (high)	II
Myotis volans, long-legged myotis	low	—
Myotis californicus, California myotis	medium, (low)	—
Myotis ciliolabrum, western small-footed myotis	medium, (low)	—
Lasiurus blossevillii, western red bat	high	II
Lasiurus cinereus, hoary bat	medium	—
Lasionycteris noctivagans, silver-haired bat	medium	—
Parastrellus hesperus, western pipistrelle	low	—
Eptesicus fuscus, big brown bat	low	—
Euderma maculatum, spotted bat	medium, (high)	II
Idionycteris phyllotis, Allen's big-eared bat	high	II
Corynorhinus townsendii, Townsend's big-eared bat	high	II

Antrozous pallidus, pallid bat	low, (medium)	—
Tadarida brasiliensis, Brazilian free-tailed bat	low	—
Nyctinomops macrotis, big free-tailed bat	medium, (high)	II

As can be seen from the above, the conservational prioritizations of Utah bat species by WBWG and UDWR are generally comparable.

Threats to Utah bats and needs for informed management

Bats are vulnerable to many threats, both anthropogenic and natural. Their roosting requirements, roost fidelity, colonial habits (most species), low fecundity, and remarkable longevity all contribute to the vulnerability of their populations. Additionally, bat conservation in Utah is hampered by the need for more complete information about the ecology, life history, population biology, and distribution of the bats of this state.

Anthropogenic Threats

- **scientific research, collection:** Collecting of some species is considered a serious threat (e.g., see Oliver 2000, especially p 91 but also pp 12, 112, 123–124). Banding is also a threat. Collecting and researcher disturbance in nursery colonies also results in reduction of the colony or abandonment (see Oliver 2000, pp 20, 30, 83, 96, 104, 105, 118). Release of bats in daylight results in high rates of unnatural predation by hawks (see Oliver 2000, pp 83, 90–91, 112, 118). Some bat species are fragile, being especially susceptible to injury and death during capture and handling (see Oliver 2000, pp 89–90). Researcher disturbance of hibernating bats causes premature arousal and depletion of fat reserves and reduces likelihood of survival (see Oliver 2000, pp 12–13).

- **eradication ("pest" or nuisance control):** Bats inhabiting homes (attics, walls) and other buildings frequently are exterminated (see Oliver 2000, p 13, 105, 112). Since such roosts frequently are maternity and nursery colonies, the impacts of "control" are especially severe.

- **persecution, vandalism:** Deliberate, malicious persecution of bats commonly occurs in Utah and elsewhere (see Oliver 2000, pp 37, 83, 105–106, 112). The bats most susceptible to persecution are those that roost communally and that prefer roosts that are easily accessible to people, such as abandoned buildings, abandoned mines, and natural

caves. Not only are bats maliciously killed, but such vandalism also results in abandonment of roosts, including maternity and nursery roosts.

- **pesticide use:** Pesticides used for mosquito abatement, to control agricultural pests, and to control forest (timber) pests often have seriously negative effects on bats and bat populations in Utah and elsewhere (see Oliver 2000, pp 12, 37, 43, 67, 75, 83, 118).

- **abandoned mine closures (and closures of highway or railroad tunnels):** Closures of abandoned mines (and similar artificial landscape features) negatively impact bats that utilize these sites (see Oliver 2000, p 51, 96, 106). Since abandoned mines are among the preferred sites used for maternity and nursery roosts and as hibernacula by various Utah bat species, and since natural caves, which might serve as substitute roost sites, are exceedingly scarce in Utah, the negative impacts of such closures can be great.

- **mining:** There is concern that toxic ponds associated with mining poison the bats that drink from these ponds. "This problem may be particularly severe in desert areas, where water associated with mining operations may be the only water in an area" (Pierson et al. 1999).

- **timber harvest and forest management**: Timber harvest eliminates or degrades habitats of forest-dwelling bats (see Oliver 2000, pp 67). "Forest management", in which practices such as thinning of trees, removal of "fuel loads" (including snags), and creation of open understories are carried out, seriously degrade critical habitats for bats. For example, one of the rarest bats in Utah and America, Allen's big-eared bat (*Idionycteris phyllotis*), almost completely disappeared from forests in New Mexico after "forest management" was implemented (Lewis 2005).

- **livestock grazing:** Livestock grazing in riparian areas results in degradation and destruction of riparian habitats.

- **recreation:** Recreational caving and rock climbing result in disturbance and potential abandonment of roosts.

- **habitat conversion:** Loss of riparian habitat negatively impacts most, if not all, Utah bats, but is likely of most critical for foliage roosting species and foliage gleaning species. Conversion of piñon–juniper woodland to other habitat types can be expected negatively to impact some bats species (e.g., the long-eared myotis, *Myotis evotis*). Clearing of natural habitats for agriculture, grazing, urban expansion, and other purposes destroys bat habitats. (See Oliver 2000, pp 25, 58, 62, 75.)

- **wind energy production ("wind farms"):** There is much recent concern about the effects of arrays of wind turbines (wind farms) on bats. Direct mortality, especially of migratory bat species, has been found to be very high in some studies. Some recent research has shown that bats are pulled or perhaps even attracted to the turbine blades, thus maximizing mortality. Site placement of wind farms and time of operation are important factors that can be controlled and that should be considered in the planning and the operation of wind farms.

Natural Threats

Although there are many natural threats that negatively impact Utah bats, control of these natural factors is already being carried out for other human purposes (mostly economic). Thus, special attention to these threats and special actions to control them in order to benefit bats in Utah is largely unnecessary. These natural threats include:

- **drought:** Reduction or complete loss of surface water and associated insect food sources and impoverishment of riparian and other vegetation during drought negatively impacts bats.

- **fire:** Fire results in loss of bat foraging habitat.

- **bark beetle kill:** Bark beetles kill vast stands of trees (e.g., spruce), resulting in loss of forest habitat.

Actions

General principles

To conserve bat species diversity and abundance in Utah, the following types of general actions are required:

- **roosts:** Protection of roost sites, such as caves, abandoned mines, cliffs and crevices, snags, trees/foliage, and of the bats using the sites and protection, from persecution, vandalism, eradication, and unintentional disturbance (e.g., from recreation). Enhancement of other potential roost sites. With proper design or simple modifications, bridges can provide important roost sites for many species of bats. Designs of new bridges and modifications of existing bridges in Utah to favor their use by bats should be implemented. Bat houses can be used to supplement or replace available roosts (buildings) in populated areas such as cities.

- **foraging habitat conservation:** Protection of large areas of all natural habitats or plant associations from lowland desert to tree line and especially riparian communities within broader plant associations.

- **water:** Protection of natural water quality and protection (exclusion) from toxic, artificial water sources; escape features for artificial water sources that serve as death traps. Water diversions and other alterations of flow regimes that degrade bat foraging habitats and overall habitat "health" should be avoided.

- **prey:** Protection of the availability and the quality (non-toxic) of prey, i.e., arthropods (mostly flying insects, especially moths and beetles).

- **air:** Protection of open air space from lethal intrusions (e.g., wind turbines operating at night).

These general needs are addressed more specifically and in more detail below.

Minimization of anthropogenic threats

To address the anthropogenic threats to bats in Utah, listed above, the following management actions are required:

- **scientific research, collection:** Research, including collecting, handling, banding, and disturbance of Utah bats, must be carefully controlled, such as through the Certificate of Registration (permit) process of the UDWR. Mist nets should be monitored at all times. Captured bats should be released only at night and should be held for the shortest time possible. Banding should be discouraged. Entry into occupied roosts (e.g., mines, caves, attics, abandoned buildings)—especially maternity, nursery, and hibernation roosts—should be discouraged. See Appendix 2 for the Western Bat Working Group's recommendations concerning white nose syndrome.

- **eradication ("pest" or nuisance control):** Eradication of bats from homes and other buildings should be prohibited. Exclusion and alteration of illumination are preferable solutions (see Oliver 2000, p 13).

- **persecution, vandalism:** Cave (McCracken 1989) and abandoned mine roosts should be protected using bat gates or enforcement. Since persecution and vandalism are largely the result of ignorance, education concerning bats—their natural value and their benefits to human economic and other interests—should be made a priority. See the Bat Conservation International (BCI) web site ("Bats and Mines"):

http://www.batcon.org/home/index.asp?idPage=53&idSubPage=87

and (caves, mines, bat gates):

http://www.mcrcc.osmre.gov/PDF/Forums/Bat%20Gate%20Design/TOC.pdf

- **pesticides:** The use of pesticides, which is a serious threat to bats because of their food habits, their metabolism, their migratory habits, and their longevity, but also is a threat to other wildlife (e.g., peregrine falcon, osprey, bald eagle) and to people, should be minimized. Alternatives to pesticide use for mosquito abatement and for control of agricultural pests and forest (timber) pests exist and should be used.

- **abandoned mines (and abandoned highway or railroad tunnels):** Surveys of abandoned mines to determine bat use should be conducted, and mines used by bats should not be closed. To ensure human safety and to prevent vandalism, bat gates should be installed at entrances to abandoned mines used by bats.

- **mining:** Toxic ponds associated with mining (e.g., cyanide, sulfuric acid) should be covered with wire netting or otherwise made inaccessible to bats and other wildlife.

- **timber harvest and forest management**: Timber harvest should be carefully controlled and practiced in limited block sizes, especially in areas where rare bat species occur. "Forest management" is detrimental to forest-dwelling bats as well as most other species of forest-dwelling wildlife (e.g., American three-toed woodpecker, Canada lynx) and should be discontinued.

- **livestock grazing:** Livestock grazing in riparian areas is detrimental to bats and to many other species of wildlife (e.g., cutthroat trout). Livestock should be excluded from riparian zones. Education should be provided to stockmen concerning livestock tank design and escape features for bats and other wildlife (e.g., birds)—see BCI web site, "Water for Wildlife":

http://www.batcon.org/news2/pdf/bciwaterforwildlife.pdf

- **recreation:** Recreational caving and rock climbing should be carefully regulated in state and national parks and on other public lands.

- **habitat conversion:** Planning for habitat conversions, treatments, and manipulations (e.g., conversion of piñon–juniper woodland to other habitat types) should consider bats in addition to other wildlife. Clearing of natural

habitats for agriculture, grazing, urban expansion, and other purposes should be regulated or mitigated if possible.

- **wind energy production ("wind farms"):** Site placement of wind farms and times (daytime versus night) and conditions (wind speeds) of operation are important factors that can be controlled and that should be considered in the planning and the operation of wind farms. See Kunz et al. (2007),

http://www.nationalwind.org/pdf/Nocturnal_MM_Final-JWM.pdf

the National Wind Coordinating Collaborative's "Wind Turbine and Interactions with Birds and Bats: A summary of Research Results and Remaining Questions",

http://www.nationalwind.org/publications/wildlife/wildlife_factsheet.pdf

and Appendix 3 (U. S. Fish and Wildlife Service's recommendations concerning wind farms).

Acquisition of needed Information (research, inventory, and monitoring)

Knowledge of the distributions and abundances of bat species in Utah is not as complete or as detailed as is needed to guide effective management. Population trends of Utah bats are almost completely unknown. The following actions are needed to acquire knowledge necessary to guide informed management of bats in Utah:

- **biology, ecology, life history:** Research focused on aspects of basic biology and ecology, especially those that are relevant to management is needed for some Utah species. Aspects of the basic biology of several of the bat species that occur in Utah are unknown (e.g., where they roost during the day, what they do during winter) (see "unknown" entries in species summaries above and species accounts in Oliver 2000). Many of these unknowns would be suitable for graduate student research.

- **distribution:** Systematically conducted statewide surveys of all bat species should be carried out in order to clarify their distributions in Utah.

- **abundance:** Systematically conducted statewide abundance inventories of all bat species are needed to ascertain their abundances in Utah.

- **monitoring:** Population trends (i.e., changes in abundance) and changes in distribution should be determined through systematically conducted statewide monitoring. Methods for monitoring of populations should be

developed. Population monitoring is probably the most important tool for guiding and evaluating management.

water: A catalogue of all surface waters in Utah, including very small ones such as livestock tanks, should be produced.

Implementation of data collection

The U. S. Department of Defense (DoD) in 2006 funded an on-going series of initiatives, being carried out by DoD in collaboration with UDWR, intended to address and fill many of knowledge gaps and information needs that limit the informed guidance of bat management in Utah that are discussed in this conservation plan. These initiatives are called Legacy I, Legacy II, and Legacy III. See Appendix 4 for summaries of Legacy I and Legacy II. Legacy I–III are described briefly below.

<u>Legacy I</u>

Assemblage of all locational and associated data for bats in Utah was accomplished under Legacy I, resulting in the compilation of many thousands of records in a database completed in 2008.

<u>Legacy II</u>

Beginning in 2008, the main goal of Legacy II is to analyze the data assembled under Legacy I. Field work (bat inventory and monitoring) will also be carried out as part of Legacy II. A Utah bat database, “BatBase”, is being constructed. Bat researchers are encouraged to contribute Utah bat data to this database.

<u>Legacy III</u>

It is anticipated that Legacy III will implement intensive inventory and monitoring of Utah bats.

Tools for implementing actions

Species identification and collection of data

Various published references can be used for field (and laboratory) identification of bats found in Utah. A field key for identification of bats in hand in Utah is provided as Appendix 5 (Witt, Kozlowski, and Oliver), a field protocol for recording bat data as Appendix 6 (Kozlowski), and a field key for acoustic identification of Utah bats as Appendix 7 (Probasco). See also O’Farrell et al.

(1999) concerning acoustic identification of bats and Miller (2001) for use of acoustic methods to determine relative activity of bats.

Survey methods

The Western Bat Working Group (2003) produced a "Recommended Survey Methods Matrix" for bat species in western America and Canada using four methods commonly used in bat field surveys: mist-net capture, roost survey, "passive acoustic" (i.e., electronic bat sonar detection device alone), and "active acoustic" (i.e., electronic bat sonar detection device together with visual observation of behavior or appearance). This survey methods matrix is intended as a first step in the development of a bat survey protocol being produced by some of the participants in the WBWG. (If such a protocol becomes available, it will be referenced, summarized, or included in a future edition of this conservation plan.) For the 19 bat species known to occur in Utah, the survey methods matrix (WBWG 2003) is provided below. The possible values for the four methods, as applied to each bat species (WBWG 2003), are:

1 = preferred or highly effective
2 = effective in most habitats
3 = effective in some habitats
4 = presenting serious challenges
5 = generally not effective
U = unknown

species	**net**	**roost**	**acoust. (pass.)**	**acoust. (act.)**
M. lucifugus, little brown myotis	2	3	4	3
M. occultus, Arizona myotis	2	3	4	4
M. yumanensis, Yuma myotis	1	2	3	1
M. evotis, long-eared myotis	1	3	2	2
M. thysanodes, fringed myotis	1	3	2	2
M. volans, long-legged myotis	2	2	4	3
M. californicus, California myotis	1	4	3	1

M. ciliolabrum, w. small-footed myotis	2	3	4	4
L. blossevillii, western red bat	3	5	2	1
L. cinereus, hoary bat	3	5	2	1
L. noctivagans, silver-haired bat	1	5	4	2
P. hesperus, western pipistrelle	2	5	1	1
E. fuscus, big brown bat	1	3	3	1
E. maculatum, spotted bat	3	5	2	1
I. phyllotis, Allen's big-eared bat	3	3	2	2
C. townsendii, Townsend's big-eared b.	3	2	4	4
A. pallidus, pallid bat	1	3	2	1
T. brasiliensis, Brazilian free-tailed bat	2	1	1	1
N. macrotis, big free-tailed bat	3	5	1	1

Additional notes provided by the WBWG (2003) for use with the above matrix are reproduced below (very slightly modified here for clarity). Some of the bat species mentioned in comparisons below do not occur in or near Utah and are not mentioned elsewhere in this document.

***Myotis lucifugus*, little brown myotis**. **Netting**. Capture: Readily netted in some areas; net-avoidant in others. ID: Morphologically similar to *M. yumanensis* and *M. occultus*. Can be reliably identified using combination of morphological and acoustic data. **Roost**. Location: Frequently in man-made roosts (mines, bridges, buildings) in parts of its range. Difficult to find in most natural roosts (e.g., trees and rock crevices). Sometimes found in night roosts. ID: Highly colonial and easy to detect in man-made roosts. Often requires handling for positive identification. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Some calls/sequences diagnostic, though probably not distinguishable from *M. occultus* in areas of geographic overlap. Difficult to distinguish from other 40-kHz *Myotis*. **Active acoustic**. Flight behavior sometimes distinctive, particularly over water.

***Myotis occultus*, Arizona myotis**. **Netting**. Capture: Fairly easy to capture in nets. ID: May be difficult to distinguish from *M. lucifugus* in areas of overlap. **Roost**. Location: Roost in man-made roosts, but natural roosts dominate. Can

often be found in night roosts. ID: Easy to detect in man-made roosts; difficult in most natural roosts. Often requires handling for positive identification. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Issues currently unresolved but probably difficult to distinguish acoustically from other 40-kHz *Myotis*. **Active acoustic.** Difficult to distinguish visually.

***Myotis yumanensis*, Yuma myotis**. **Netting**. Capture: Water-skimming foraging style makes this species highly vulnerable to capture in mist-nets set over still water. ID: Morphologically similar to *M. lucifugus* and *M. occultus*. Can be distinguished from *M. lucifugus* and *M. occultus* by combination of capture and recording of hand-release echolocation call. **Roost**. Location: Commonly in man-made roosts. Form large aggregations in night roosts (particularly bridges). Difficult to locate most natural roosts. ID: Highly colonial and easy to detect in man-made roosts. Requires handling for positive identification. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Difficult to distinguish from *M. californicus*, though some calls diagnostic (50-kHz *Myotis*). **Active acoustic**. Flight behavior, particularly water skimming, distinctive.

***Myotis evotis*, long-eared myotis**. **Netting**. Capture: Readily captured in mist nets at both aquatic and terrestrial sites. ID: Morphologically distinct except in areas of overlap with *M. auriculus*, *M. keenii*, or *M. septentrionalis*. Also similarity to *M. thysanodes* in some regions. **Roost**. Location: Can be detected in man-made roosts, but often cryptic; difficult in most natural roosts (e.g., trees and rock crevices). Natural roosts dominate. Sometimes in night roosts, particularly mines and bridges, although extent to which these features are used varies regionally. ID: Small colonies. Generally crevice roosting. Often requires handling for positive identification. **Passive acoustic**. Detection: Intermediate intensity calls. ID: Subset of sequences diagnostic except in area of geographic overlap with *M. auriculus*, *M. septentrionalis*, or possibly *M. keenii*. Also possible confusion under some habitat conditions with 40-kHz *Myotis*. **Active acoustic**. May be helpful in distinguishing it from short-eared *Myotis*.

***Myotis thysanodes*, fringed myotis**. **Netting.** Capture: Readily captured in mist nets (often on secondary streams in northwestern portion of range). ID: Generally easy, but morphologically similar to *M. evotis* in some regions. **Roosts**. Location: Can be detected in man-made roosts, but difficult in most natural roosts (e.g., trees and rock crevices). Natural roosts dominate. Sometimes found in night roosts. ID: Small colonies and often in crevices. Requires handling for positive identification. **Passive acoustic**. Detection: Intermediate intensity calls. ID: Many sequences/calls diagnostic. Possible confusion with *A. pallidus*. **Active acoustic**. Flight behavior, in combination with call morphology, sometimes helpful.

***Myotis volans*, long-legged myotis**. **Netting**. Capture: Effectiveness of netting varies regionally, and setting makes a difference. ID: Morphologically distinct. **Roost**. Location: Can be found in man-made roosts; difficult in most natural

roosts. Natural roosts dominate. Often found in night roosts. ID: Requires handling for positive identification. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Issues currently unresolved with other 40-kHz *Myotis*. **Active acoustic**. Flight behavior can be distinctive (long tail membrane).

***Myotis californicus*, California myotis**. **Netting**. Capture: Readily captured in mist nets. ID: Morphologically similar to *M. ciliolabrum*. Can be distinguished from *M. ciliolabrum* by combination of capture and recording of hand-release echolocation call. **Roost**. Location: Can be found in man-made roosts, but generally non-colonial and crevice-roosting; most roosts not man-made and difficult to find. Sometimes found in night roosts. ID: Requires handling for positive identification. **Passive acoustic**. Detection: Easy. ID: Difficult to distinguish from *Myotis yumanensis* (50-kHz *Myotis*). **Active acoustic**. Flight behavior distinguishes it from *M. yumanensis* in most settings.

***Myotis ciliolabrum*, western small-footed myotis**. **Netting**. Capture: Readily captured in nets in some portions of its range, but vulnerability to netting may vary regionally. ID: Morphologically similar to *M. californicus*. Can be reliably identified using combination of morphological and acoustic data. **Roost**. Location: Predominantly non-colonial. Frequently in mines, but natural roosts likely dominate and difficult to find. Sometimes found in night roosts. ID: Roost in small groups. Requires handling for positive identification. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Not currently distinguishable from other 40-kHz *Myotis*. **Active acoustic**. Can sometimes be distinguished when observed in flight, but requires experience.

***Lasiurus blossevillii*, western red bat**. **Netting**. Capture: Sometimes captured in mist nets, but foraging areas often not suitable for netting (e.g., over large water sources). ID: Morphologically distinct except where overlaps with *L. borealis*. **Roost**. Location: Non-colonial. Very difficult to locate tree roosts. ID: Difficult to locate bats in foliage, easy to ID except where overlaps with *L. borealis*. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Most sequences diagnostic in areas without *L. borealis*. In areas with *L. borealis*, extensive acoustic overlap, but probably distinguishable statistically. Some acoustic overlap with *P. hesperus*. **Active acoustic**. Distinctive in flight except in areas with *L. borealis*.

***Lasiurus cinereus*, hoary bat**. **Netting**. Capture: Fly high; often under-represented in net captures. Often foraging in areas that cannot be feasibly netted. ID: Morphologically distinct. **Roost**. Location: Non-colonial. Very difficult to locate tree roosts. ID: Difficult to locate bats in foliage but easy to distinguish from other species. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Many calls diagnostic throughout much of its range; subset of calls overlap with *T. brasiliensis* and *N. femorosaccus*. **Active acoustic**. Distinctive in flight.

***Lasionycteris noctivagans*, silver-haired bat**. **Netting**. Capture: Vulnerability to net capture varies with habitat, but generally quite susceptible to capture. Captured over water sources (large and small). ID: Morphologically distinct. **Roost**. Location: Very difficult to locate in natural roosts (e.g., trees and snags). ID: Unlikely to locate via roost search but, can be distinguished visually in flight upon exit. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Some calls distinctive, but overlap with *T. brasiliensis* and *E. fuscus*. In areas without *T. brasiliensis*, many sequences are diagnostic. **Active acoustic**. With experience can be distinguished visually in flight.

***Parastrellus hesperus*, western pipistrelle**. **Netting**. Capture: Captured in nets fairly readily, although often fly high. ID: Morphologically distinct. **Roost**. Location: Predominantly cliff-roosting. Some roosting in man-made structures, particularly mines. ID: Usually non-colonial or small colonies. Can be identified visually at very close range. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Most calls diagnostic, although some overlap with *L. blossevillii*. **Active acoustic**. Visually distinctive.

***Eptesicus fuscus*, big brown bat**. **Netting**. Capture: Readily captured in mist nets, but problematic in open areas, especially where water is abundant. ID: Morphologically distinct. **Roost**. Location: Easy to locate man-made roosts; difficult in most natural roosts (e.g., trees and rock crevices). Natural roosts dominate throughout much of range. Night roost surveys often effective. ID: Colonies often conspicuous, species easy to ID. **Passive acoustic**. Detection: Easy. ID: subset of sequences diagnostic acoustic overlap with *L. noctivagans* and *T. brasiliensis*. **Active acoustic**. Visually distinctive in flight.

***Euderma maculatum*, spotted bat**. **Netting**. Capture: Can be effective where water is a limiting factor in xeric conditions, although netting is not effective in many portions of range. ID: Morphologically distinct. **Roost**. Location: Non-colonial, cliff-roosting; very difficult to locate and generally inaccessible. ID: Unknown; no roosts have been visually inspected; only locations have been from a distance using radio-telemetry. **Passive acoustic**. Detection: Easy to detect acoustically (with microphones sensitive to audible frequencies). Calls are audible to many people. ID: Most sequences diagnostic, except in areas of geographic overlap with *I. phyllotis*. **Active acoustic**. Difficult to distinguish from *I. phyllotis*; otherwise distinctive in flight.

***Idionycteris phyllotis*, Allen's big-eared bat**. **Netting**. Capture: Captured infrequently in mist nets; show loyalty to particular water sources, but may be difficult to locate in initial surveys. ID: Morphologically similar to *C. townsendii*. **Roost**. Location: Easy to detect in man-made roosts (e.g., mines); difficult in natural roosts (e.g., trees, rock crevices). ID: Easy: roost in clusters on open surface (e.g., domes of mines). May be confused with *C. townsendii*. **Passive acoustic**. Detection: Easy to detect acoustically (with low frequency microphone). ID: Most sequences diagnostic, except can be difficult to

distinguish from *E. maculatum*. Geographic overlap with *E. maculatum* throughout much of its range. Highly distinctive social call. **Active acoustic**. Can be difficult to distinguish from *E. maculatum*.

***Corynorhinus townsendii*, Townsend's big-eared bat**. **Netting**. Capture: Effective at avoiding mist-nets. ID: Morphologically similar to *I. phyllotis*. **Roost**. Location: Most effectively found by searching for colonial roosts, in mines and caves. Roosts in buildings in coastal portion of range. Some portions of range, particularly Canada and some desert areas, roosts very difficult to locate. ID: Easy to locate and ID in roost. **Passive acoustic**. Detection: Difficult to detect acoustically, low intensity calls ("whispering bat"). ID: Calls, when detected, are diagnostic. **Active acoustic**. Visually distinctive in most settings.

***Antrozous pallidus*, pallid bat**. **Netting**. Capture: Fly low to ground and readily captured in nets (often in upland habitats). ID: Morphologically distinct. **Roost**. Location: Easy to detect colonies in man-made roosts; difficult in most natural roosts (e.g., trees and rock crevices). Frequently uses man-made roosts (mines, bridges, buildings) in parts of its range. Often found in night roosts, especially mines and bridges. ID: Roost conspicuously, easy to ID. Guano with characteristic culled insect parts (particularly Jerusalem crickets and scorpions) often distinctive. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Subset of calls diagnostic, particularly if it gives a "directive" call. **Active acoustic**. Visually distinctive.

***Tadarida brasiliensis*, Brazilian free-tailed bat**. **Netting**. Capture: While sometimes captured in mist nets, this species flies high and is generally more abundant than net captures would suggest. ID: Generally distinctive, but potentially confused with *N. femorosaccus*. **Roost**. Location: Highly colonial and easy to detect in man-made roosts; difficult in most natural roosts. Natural roosts (e.g., cliff roosts) dominate in large portion of range. Commonly in man-made roosts in portion of its range. ID: Easy to locate and ID in most roosts. Guano and odor distinctive. **Passive acoustic**. Detection: Easy to detect acoustically. ID: Some calls overlap with other species (*L. noctivagans*, *E. fuscus*, *L. cinereus*, *N. femorosaccus*), but fair proportion are diagnostic. In most settings this would be the easiest way to detect the species. **Active acoustic**. Visually distinctive except where overlaps with *N. femorosaccus*.

***Nyctinomops macrotis*, big free-tailed bat**. **Netting**. Capture: Records extremely limited suggesting serious challenges. ID: Morphologically distinct. **Roost**. Location: Generally cliffs and rock crevices; often inaccessible. Also known to use building and tree roosts. Guano deposits and chatter can potentially be used to locate roosts, but generally not effective. ID: Generally requires monitoring at emergence. **Passive acoustic.** Detection: Easy to detect acoustically (best with low frequency microphone); calls in audible range for some people. ID: Most calls diagnostic, but overlap with *E. underwoodi* and

possibly *E. perotis*. Species poorly known. **Active acoustic**. Indistinguishable from *Eumops* spp. in flight.

Survey protocol and predictive bat habitat model

A bat survey design, adapted from that of Keinath (2001), has been developed by Kozlowski and Green (UDWR, TNC, UBCC). This survey design developed for Utah has been used to produce a predictive model of bat habitat (Appendix 8) and a map of predicted important bat habitat.

Frequently asked questions

How can I get rid of bats in my attic, walls, or other parts of my house?

Pest control companies often charge excessive fees to eliminate bats from attics of homes and from other buildings or structures, and they often deliberately or inadvertently harm or kill the "problem" bats, sometimes including pregnant or nursing females and their young. In most cases homeowners can easily exclude bats from a residence without harming the bats and at little or no cost. The web site of Bat Conservation International (BCI) provides details on how to do this:

http://www.batcon.org/home/index.asp?idPage=51
http://www.batcon.org/home/index.asp?idPage=51&idSubPage=48
http://www.batcon.org/home/index.asp?idPage=51&idSubPage=49

Basically, you would need to observe your house in the evening to determine where the bats exit the attic and then to tape plastic sheeting over the exit openings. (There may be several places that the bats exit and enter the attic.) The tape should attach the top and both sides of the piece of plastic sheeting to the structure, but not the bottom, which should extend down several inches below the opening. The plastic could be whatever you have available, even pieces cut from a plastic bag. Bats in the attic will crawl down and out through the unattached bottom of the plastic. When the bats return, they will not be able to find a way back into the attic because of the plastic, provided that you put plastic, in the way mentioned, over all of their exit and entrance points.

It is best to do this between 15 September and 31 October or between 15 March and 30 April in order to avoid exclusion when the bats are going into hibernation (winter) and when maternity and nursery activities are taking place (summer). In summer there may be young bats, perhaps still nursing and too young to fly, that would die in the attic as a result of having their mothers prevented from caring for them. In winter there is some bat activity on warmer nights, and bats could be excluded when access to the hibernation roost is critical for their survival.

You could also consider allowing the bats to remain in the attic. Unless you or your family members regularly enter the attic, it is unlikely that the presence of the bats would represent any health threat to you or your family. Another option would be to construct and place bat houses on your property. The BCI web site mentioned above provides plans for constructing bat houses and suggestions for their placement (see below). Bat houses could be used in combination with the exclusion technique mentioned above.

How can I attract bats to my property?

Bats often are not very noticeable and can easily be missed even when they are present. Most of the bat species that occur in Utah produce vocalizations that are not audible to people. Thus, you may already have bats on your property or at least in the air space above your property. There are, however, various things that could enhance the attractiveness of your property to bats. You may wish to consider installing bat houses (artificial roosts) on your property. Bats require drinking water, and ponds are attractive to them. Many bats pick their prey from foliage, rather than in the air, and trees can provide suitable foraging sites. Trees also provide suitable roosts for some species of Utah bats. Some Utah bats roost among foliage and others use cavities in the trunks of trees.

Where can I get, or how can I build, a bat house?

Most commercially available bat houses are not adequate, being of poor design and too small. The web site of Bat Conservation International (BCI) provides very good plans for building bat houses:

http://www.batcon.org/home/index.asp?idPage=47
http://www.batcon.org/pdfs/BatHouseCriteria.pdf
http://www.batcon.org/pdfs/SingleChamberBHPlans.pdf

How can I get bats to use a bat house?

Success using bat houses is quite unpredictable. Installing a bat house of good design and of adequate size does not guarantee that the bats will use the bat house, even if many bats are present. Why this is so is not well understood, but it appears to be related to the placement of the bat house, especially relative to the sun, since temperatures in side the bat house must be within a certain range required by the bats. If you have installed bat houses but had no success in attracting bats to them even when bats are present, try, after a failed summer season, moving the bat houses to different locations, experimenting with whether the bat house is exposed to the sun, at what time of day its gets sun (if any),

height above the ground, and its placement relative to trees, buildings, etc. The BCI web site discusses suitable placement for bat houses:

http://www.batcon.org/pdfs/BatHouseCriteria.pdf
http://www.batcon.org/pdfs/AttractingBats.pdf

If I attract bats to my property, will they control mosquitoes?

Despite much misinformation in the popular media, bats in Utah and America do not control mosquitoes. While it may be true that many species of bats that occur in America *potentially* could eat 600 mosquitoes in an hour, it is unlikely that any actually do this. Most of the bats species that occur in Utah eat primarily moths, and those that do not eat primarily moths eat primarily beetles. Some of them probably do eat some mosquitoes, especially if they are not finding many moths to eat on a particular night, but none prefer or specialize in eating mosquitoes. If moths are available, even a medium-sized moth contains many times the energy or food value of a mosquito. Thus it's not worth the bat's expenditure of energy to pursue tiny prey like mosquitoes when there are bigger prey like moths to eat.

None of the above is meant to discourage you from trying to attract bats, such as by providing bat houses, but only to be truthful and not to create unrealistic expectations. Assuming that you were successful in attracting bats to occupy bat houses on your property, they might actually reduce the mosquito population somewhat.

There are many good reasons, aside from mosquito control, to seek to attract bats to your property. Bats are fascinating animals, and watching their evening exit flights from a bat house on summer nights can be very enjoyable. Also, some people put buckets or other containers beneath a bat house to collect the guano that falls from an occupied bat house. Bat guano is one of the best fertilizers known, and it is natural. It is sold in some nurseries and gardening stores in Utah for very high prices.

If I find a bat, should I send it to be tested for rabies?

If you find a bat, it is best to leave it alone. Unless a bat is known to have bitten someone or has been in room with a person who is unable to communicate, there is no need to have the bat tested for rabies.

The BCI web site answers many questions pertaining to bats and rabies:

http://www.batcon.org/home/index.asp?idPage=91&idSubPage=62

You can safely move a bat outside or away from a dwelling by scooping it up in a box or other container or, wearing heavy gloves, with your hands. If it is summer, place the bat in the shade, preferably in a tree or in an elevated situation and out of the reach of cats and dogs. If it is winter, place the bat in a sunny location, near some protective cover that it can retreat to, and in an elevated situation from which it may be able to take flight.

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Appendix 1. Ecological integrity tables for Utah bats

Allen's big-eared bat (*Idionycteris phyllotis*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	habitat	diurnal roosts	—	—	rock crevices in cliff faces	exfoliating bark of large, dead trees ("snags"); abandoned mines; caves, rock shelters	Barbour and Davis (1969) Rabe et al. (1998), Brown and Berry (2005), other authors	
condition	habitat	maternity roosts	—	—	—	abandoned mines, boulder piles in caves	Commissaris (1961), Cockrum and Musgrove (1964)	Few maternity roosts have been found, and knowledge of the acceptable range of conditions is thus very limited.
landscape	habitat	elevation*	<2,500 ft or >9,800 ft	2,500–3,500 ft or 8,500–9,800 ft	3,500–5,000 ft or 7,500–8,500 ft	5,000–7,500 ft	Genoways and Jones (1967), Barbour and Davis (1969), Czaplewski (1983), Oliver (2000)	

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	plant associ-ation*	—	piñon–juniper woodland, mountain brushland, mixed forest, lowland riparian woodland, desert shrub, sagebrush steppe, mesquite grassland	oak–juniper woodland, mixed coniferous forest	ponderosa pine forest	Czaplewski (1983), Oliver (2000), Barbour and Davis (1969), Lewis (2005), Brown and Berry (2005), Jones (1965)	This species has been found, at least occasionally, in most habitats that are present within its limited range, and it is uncertain what constitutes unsuitable habitat within its range. Most mist-net captures have been at ponds in ponderosa pine forest, which is considered to be preferred or optimal habitat.
landscape	habitat	physio-graphy (perhaps related to roost availability)	—	lava flows	rocky slopes	cliffs, canyons	various authors (e.g., Czaplewski 1983)	
landscape	habitat	forest manage-ment*	managed (i.e., by thinning and removing “fuel loads”)	—	—	unmanaged	Lewis (2005)	
landscape	roosting habitat	closure or “reclama-tion“ of abandoned mines	complete closure (e.g., back-filling or dynamiting of entrances)	gating with “bat friendly” gates	none	none	various authors (e.g., Brown and Berry 2005)	

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	**Fair**	**Good**	**Very Good**		
landscape	roosting habitat	vandalism and other human disturbance (including scientific investiga-tion) of roosts, such as abandoned mines	recurring	infrequent	isolated instances	none	Barbour and Davis (1969)	

[1]The ecology of this species is not well known; of all the bat species that occur in America, it is one of (if not *the*) most poorly known species. Incomplete knowledge often leads to incorrect generalizations, and it is possible that partial knowledge of Allen's big-eared bat has resulted in distorted beliefs about the requirements of this species. It has often been stated that this species is primarily a dweller of forested mountainous areas (e.g., Barbour and Davis 1969, Czaplewski 1983); however, recent work (e.g., Brown and Berry 2005) suggests that this is too narrow a generalization. Also, like many bat species, Allen's big-eared bat may roost in one habitat and forage very widely in other habitats. Brown and Berry (2005) found that Allen's big-eared bats traveled ~70 km roundtrip nightly from roosts in one habitat to foraging areas in other habitats (at different elevations and in different plant associations). The wintering habits of this species (migration versus hibernation) are unknown (Czaplewski 1983). Its closest relatives hibernate in caves and mines.

*Most important indicators.

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Arizona myotis (*Myotis occultus*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	elevation*	>9,000 ft	—	<6,000 ft	6,000–9,000 ft	Jones (1965), Barbour and Davis (1969), Hoffmeister (1986)	“Although this species is found in the low desert along permanent water courses, it is most commonly encountered in the pine forests at 6,000–9,000 feet elevation” (Barbour and Davis 1969). “In New Mexico, *M. occultus* is known from low-elevation riparian areas in the Rio Grande Valley and montane highlands . . .” (Piaggio et al. 2002).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	plant association (uncertain import-ance, see Comments)	other (piñon–juniper–oak woodland)	—	riparian woodland (cotton-woods, willows, sycamores)	coniferous (e.g., ponderosa pine, spruce, fir) forest, oak–ponderosa pine woodland, desert shrub and grassland	Jones (1965), Barbour and Davis (1969), Hoffmeister (1986), Morrell et al. (1999)	Barbour and Davis (1969) stated: "*M. occultus* seems to be most common in the high country of New Mexico and Arizona where it is a resident of fir, spruce, and ponderosa pine forests." However, Findley et al. (1975) wrote of this taxon (as *M. lucifugus*) in New Mexico: "Vegetation zone seems unimportant in determining their distribution." In the Mogollon Mountains of New Mexico and Arizona, Jones (1965) found this species to be equally common in desert scrub–grassland and in montane coniferous forest but completely absent from the piñon–juniper–oak woodland between these 2 inhabited zones.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	proximity to permanent water*	far	—	—	near	Barbour and Davis (1969), Findley et al. (1975), Hoffmeister (1986)	Geluso (1975, 1978) found experimentally that the urine-concentrating ability of *M. lucifugus occultus* was poor relative to some other bats (of 10 other species, mainly from New Mexico). Bats of this taxon died if they were fed but deprived of water for 12 h.
landscape	habitat	roosts, including maternity roosts	mines, caves	—	—	buildings, bridges, snags (e.g., ponderosa pine and Douglas-fir)	Barbour and Davis (1969), Findley et al. (1975), Hoffmeister (1986), Rabe et al. (1998)	

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	roosts, habitat	forest manage-ment that removes snags	occurring	—	—	none	Rabe et al (1999)	“To manage snags for bat habitat, sufficient numbers of large trees should be retained and allowed to die in place, and all existing snags should be preserved. . . . 5 snags/ha (in ponderosa pine habitats) . . . may be insufficient to provide long-term availability of bat roost snags” (Rabe et al. 1999).
condition	mortality, loss of roosts	eradication from buildings	occurring or suspected	—	—	none		
condition	mortality	pesticide use	occurring in vicinity	—	—	none in vicinity		Barbour and Davis (1969), citing another source, mentioned that bats of this species “have been observed foraging in an orchard”.

[1]This taxon has had an unstable history, especially in recent decades (see Oliver 2000 for discussion). It has been regarded as a subspecies of *Myotis lucifugus* by some authors and as a full species by others. From the time of its naming in 1909 until 1967 this taxon was considered a species, but from 1967 until 2002 most mammalogists considered *occultus* to be a subspecies of *M. lucifugus*. The majority view among American mammalogists has shifted again, since 2002; seemingly most mammalogists currently regard *occultus* again as a species, based on the work of Piaggio et al. (2002). Ironically, 2 of the authors of that work (i.e., Piaggio et al. 2002) had demonstrated 3 years earlier (Valdez et al. 1999) that *occultus* was not a species. The taxon *occultus* is here treated as putative species. This taxon occurs in s. Colorado, New Mexico, Arizona, se. California, n. Chihuahua, c. México (Distrito Federal), possibly w. Texas, possibly s. Utah,

possibly s. Nevada, and possibly other parts of México. Valdez (2003) indicated that *occultus* occurs in s. Utah, but Piaggio et al. (2002, of which Valdez was an author) considered s. Utah to represent a hiatus between the ranges of *M. lucifugus carissima* and *M. occultus*. Based on unconfirmed reports such as that of Valdez (2003), it is here considered that *occultus* may occur in s. Utah but that this is in need of verification. This table is intended for use mainly in the American southwest and Chihuahua.

*Most important indicators.

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big brown bat (*Eptesicus fuscus*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	water	distance to permanent surface water (fresh) (This indicator is somewhat speculative—see Comments.)	>5 km	2–5 km	1–2 km	<1 km	see Comments	In the experiments of Geluso (1978), the urine-concentrating ability of *E. fuscus* was near the middle of the overall range for the 11 insectivorous bat species that he tested (mostly from New Mexico). This suggests a moderate degree of dependence upon availability of drinking water, and proximity to an open source of surface water may be a requirement for this species. *E. fuscus* is considered not to forage widely from its roosts, typically only 1–2 km (Kurta and Baker 1990, Kurta 1999). However, some Utah data suggest that *E. fuscus* may fly 3–4 mi (4.8–6.4 km) from roosts to reach water.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	mortality, impaired reproduction, reduction of prey base	application of pesticides, other toxins (e.g., PCB)	occurring in immediate vicinity (<1 km)	occurring very near (1–2 km)	occurring somewhat nearby (2–5 km)	none in general vicinity (>5 km)	Luckens and Davis (1964), Barbour and Davis (1969), Henny et al. (1982), Kurta and Baker (1990)	Relative to other tested mammals (lab animals), *E. fuscus* is extremely sensitive to DDT—10 times as sensitive as lab mice (Luckens and Davis 1964) and is especially sensitive to DDT in spring when emerging from hibernation (Barbour and Davis 1969). *E. fuscus* was 1 of the bat species that showed an increase in pesticide residues in its tissues after spraying of DDT to control the Douglas-fir tussock moth in forests of ne. Oregon (Henny et al. 1982). Kurta and Baker (1990), citing others, wrote of *E. fuscus*: “Man-made chemicals (DDT, DDE, PCB, dieldrin, methyl parathion) are concentrated in milk, embryos, and adult tissues and may cause death . . . .” (See distances discussed above.)

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	mortality	eradication (“pest control”), persecu-tion, vandalism, or disturbance in houses, other buildings, other man-made structures, caves, mines	occurring or presumed to occur	—	—	none	Kurta and Baker (1990), Oliver (2000)	Because this species commonly roosts in houses(attics, walls, or basements), other buildings, and other man-made structures, it is often regarded as a nuisance and is vulnerable to eradication (Kurta and Baker 1990, Kurta 1999) and to malicious persecution (Oliver 2000). Similarly, it often roosts in caves and mines, where it also falls victim to intentional persecution and vandalism, or simply to unintentional disturbance. In houses where it is considered a nuisance, it should be non-lethally excluded (Kurta and Baker 1990, Kurta 1999), but this should not be done during summer when non-volant young are present (Kurta 1999).

[1]This species occurs from Alaska and Canada (n. Alberta) through most of America, México, and Central America to Colombia, Venezuela, and n. Brazil. (It has been suggested that *E. fuscus* is a synonym of *E. serotinus*; if so, its range also includes Eurasia.) *E. fuscus* is an ecological generalist, occurring in most habitats within its great range. In Utah it is found in nearly all habitats (plant associations), from desert shrub to montane forest (Oliver 2000), as it is in Arizona (Hoffmeister 1986). Reported captures in Utah range from the lowest elevations in the state to 9,200 ft, and acoustic detection as high as 10,560 ft has been reported (see Oliver 2000). Similarly, in Arizona Hoffmeister (1986) captured this species as high as 9,400 ft but believed that it occurs above 10,000 ft. *E. fuscus*, in Utah and elsewhere, occurs in cities and towns and in agricultural areas in addition to natural habitats. It roosts (day, night, maternity, and hibernation) in a wide variety of natural and man-made situations. Thus, there are almost no ecological limitations for this species in Utah except perhaps availability of water.

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big free-tailed bat (*Nyctinomops macrotis*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	plant association	other	montane coniferous forest, montane mixed forest	tropical and temperate woodland, tropical deciduous forest, tropical thorn forest, tropical oak forest	lowland riparian, desert shrub	Milner et al. (1990), Oliver (2000)	
landscape	habitat	physical character-istics*	—	—	—	"rugged, rocky country"	Barbour and Davis (1969), Milner et al. (1990)	This indicator may not apply in some places in the Neotropics.
landscape	habitat	roosts*	other	tree cavities	buildings, caves	rock crevices in cliffs	Milner et al. (1990)	
landscape	nursery colonies	height of crevice (e.g., in cliff face)	«40 ft	<40 ft	≥40 ft	»40 ft	Milner et al. (1990)	Indicator is based on only 2 reported observations.
landscape	habitat	elevation*	>9,200 ft	7,550–9,200 ft	5,900–7,550 ft	<5,900 ft	Milner et al. (1990), Oliver (2000)	

[1]This species ranges from Utah and Colorado (with extralimital records from as far north as British Columbia) through Central America and the Greater Antilles to Uruguay and northern Argentina. Its ecology is not well understood and apparently varies greatly across this great region. There are also many areas within its overall range that appear to provide suitable habitat for the species but from which it appears to be absent (Barbour and Davis 1969). **This table is intended primarily for use in western North America**. The "very good" indicator ratings mostly pertain to the arid lands of the American southwest and México and may not be applicable in other areas such as the Neotropics.

*Most important indicators.

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Brazilian free-tailed bat (*Tadarida brasiliensis*) Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	setting	—	—	natural, agricultural	urban	various sources including Oliver (2000)	In Utah this species is most abundant in urban areas, but it is also common in many natural habitats and in agricultural areas.
landscape	habitat	plant association (Utah) (natural rather than agricultural or urban)	other forest types (e.g., aspen, spruce–fir), alpine tundra	ponderosa pine forest	woodland (e.g., piñon–juniper), shrub-steppe (e.g., sagebrush)	desert shrub, lowland riparian	various sources including Oliver (2000)	Other plant associations are inhabited elsewhere.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	maternity and nursery sites	roosts (Utah)	other (e.g., caves, mines)	—	crevices in cliff faces	buildings	Oliver (2000)	Throughout its range this species uses a wide variety of situations for roosts, including abandoned mines, bridges, culverts, and perhaps hollow trees. In some places (e.g., parts of TX, OK, NM, AZ, and México) large caves are the preferred sites, some caves being inhabited by many millions of adult females (up to 20 million) and their young. However, in Utah caves and mines are not used by this species, although there is a possibility that 1 cave in Utah has served as a roost (see Oliver 2000).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat, thermal biology	elevation (Utah)	>8,000 ft	6,000–8,000 ft	5,000–6,000 ft	<5,000 ft	Oliver (2000)	Barbour and Davis (1969) wrote: "In the West *T. brasiliensis* is most characteristic of the Lower and Upper Sonoran life zones. It commonly ranges into the Transition Zone and occasionally wanders into the mountains at least to 9,200 feet." Reported elevations of capture of this species in Utah range from the lowest elevations in the state to 8,000 ft (Oliver 2000). Acoustic detection has been reported as high as 10,560 ft in Utah (see Oliver 2000), but confirmation based on capture of this bat at such high elevation would be desirable.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	mortality	application of pesticides (distance to sources such as cities or agricultural areas[2])	occurring within 50 km (30 mi)	—	—	none within 50 km (30 mi)	Wilkins (1989), McCracken (1999)	"Tissues of *T. brasiliensis* collected in California, Arizona, New Mexico, and Texas contained various combinations of residues of the organochlorine compounds DDT, DDE, DDD, dieldrin, endrin, toxaphene, and the PCBs Aroclor 1254 and 1260, with DDE occurring in higher concentrations than the other contaminants . . . . Tissue concentrations of pesticide residues were greater for bats collected in cities and close to agricultural activities than for bats obtained . . . remote from humans . . . . Pesticide poisoning is probably the primary agent responsible for drastic declines in some populations of *T. brasiliensis* . . ." (Wilkins 1989).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	mortality	production of heavy metals (distance to sources such as mining operations, smelters[2]) see Comments	occurring within 50 km (30 mi)	—	—	none within 50 km (30 mi)	Wilkins (1989)	"Heavy metals, such as mercury, lead, and selenium, can be incorporated into the tissues of *Tadarida brasiliensis* . . . . The trend of mercury content in annual strata of guano deposits in a cave near Morenci, Arizona, tracked the production figures of a copper smelter located 8 km away; the mercury probably entered the bats via the food chain . . ." (Wilkins 1989, citing others).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	mortality	disturb-ance, vandalism, and eradication ("pest control") at roost sites	occurring or believed to occur	—	—	none	McCracken (1999)	"Declines and extirpations of several formerly large colonies have been documented in recent years, both in the United States and Mexico. Poisoning by agricultural pesticides may have a role in the decline of Brazilian free-tailed bat populations, but the major factor is the disturbance and destruction of roost sites by humans" (McCracken 1999). In Utah the largest colonies roost in buildings, where they are often considered a nuisance and a health hazard. Such colonies should not be eradicated; instead, non-lethal exclusion of bats from the building should be used, though not during summer when non-volant young may be present.

[1]This species occurs across the southern parts of America (Atlantic to Pacific coasts), through México and Central America, on most of the Caribbean islands, and in parts of South America, south to c. Chile and c. Argentina. The ecology of this bat differs considerably in various regions within its great geographic range. **This table is intended for use primarily in Utah**, and much of it is not applicable in other parts of the range of *T. brasiliensis*, even within America.

[2]"Brazilian free-tailed bats often fly 50 km or more to reach foraging areas . . ." (Wilkins 1989, citing another source). "At Carlsbad Caverns the [Brazilian free-tailed] bats travel about 40 miles [64 km] to reach their feeding areas . . . . How far a colony of several million [Brazilian free-tailed] bats disperse to feed is not known. [Other authors] believe that they do not go much beyond 50 miles [80 km]" (Barbour and Davis 1969).

*Most important indicators.

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gvo

California myotis (*Myotis californicus*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
size	population	acoustically detected "passes" per 5-min period (uncertain —see Comments)	<0.5	0.5–1	1–2	>2	Bell (1980)	In the Chiricahua Mountains of se. Arizona, Bell (1980) recorded ultrasonic vocalizations of bats in 3 habitats (juniper scrub, riparian forest, and desert) throughout the night. For *M. californicus* these acoustic records of "passes" ranged 0.13–3.64 per 5-min sample periods. Whether his data (and the ratings assigned here) are generally applicable as a measure of population is uncertain.
landscape	habitat	plant association (Utah)	alpine tundra	montane grassland, aspen forest, mixed forest	rabbitbrush, greasewood, sagebrush, juniper, piñon	desert shrub, lowland riparian	Oliver (2000)	This species occurs in other habitats (e.g., wet coastal forests, other forest types, lowland grasslands) elsewhere.
landscape	hibernacula	feature, structure*	—	—	caves, buildings	abandoned mines	Oliver (2000), Barbour and Davis (1969), other sources	

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	maternity, nursery roosts	feature structure	—	—	—	rock crevices, buildings, snags	Krutzsch (1954), Barbour and Davis (1969)	In forests (>140 y old) in British Columbia, Brigham et al. (1997) found that pregnant and lactating females of this species roosted in areas of low canopy closure and in large, dead trees (snags), especially Douglas-fir and ponderosa pine, the latter much more often than expected based on relative abundance.
landscape	habitat, thermal biology	elevation*	>9,000 ft	7,500–9,000 ft	6,000–7,500 ft	<6,000 ft	Oliver (2000), Barbour and Davis (1969)	
condition	roost sites, habitat	forest manage-ment involving removal of snags	existing	—	—	none	Brigham et al. (1997)	Brigham et al. (1997) concluded that "retention and recruitment of snags in managed forests may be crucial for the conservation of bats", including this species.

[1]This species occurs throughout much of western North America (mainly west of the Rocky Mountains) from se. Alaska to Guatemala, and its ecology varies in different parts of its large range. **This table is intended for use primarily in Utah**.

*Most important indicators.

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fringed myotis (*Myotis thysanodes*)[1]
Ecological Integrity Table[2]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	thermal biology	elevation*	>9,350 ft	7,000–9,350 ft	<4,000 ft	4,000–7,000 ft	Barbour and Davis (1969), O'Farrell and Studier (1980), Oliver (2000)	The "fair" rating is an interpolation.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	habitat	plant associ-ation[3] (see Comments and footnote 3)	other	shrub steppe, grassland (uncertain—perhaps “good” [3])	coniferous forest, mixed forest	oak, piñon, and/or juniper woodland, desert scrub	various sources including Barbour and Davis (1969), O’Farrell and Studier (1980), Oliver (2000)	Most habitats utilized by this species are arid, although wet coastal forests are inhabited in Oregon. O’Farrell and Studier (1980) commented: “All desert and steppe areas within the range of *M. thysanodes* were within an hour flight from forested or riparian areas.” Average flight speed in this species has been determined (experimentally) as 8.6 mi (13.8 km) per hour. O’Farrell and Studier (1980) stated that “[o]ak and pinyon woodlands appear to be the most commonly used vegetative associations”, and Barbour and Davis (1969) considered it to be a resident of “oak, piñon, and juniper . . . and desert scrub”. Many habitats are used; “ratings” uncertain.[3]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	reproduction (maternity), hibernation (uncertain)	loss, alteration, or disturbance of roosts (e.g., disturbance or destruction of abandoned buildings, abandoned mine closures, removal of large snags and decadent trees [forest management], recreational cave and mine exploration)*	occurring	—	—	none	various sources	O’Farrell and Studier (1980) noted, with regard to roosts: “This species seems easily disturbed by human presence.”

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	loss or degradation of habitat (e.g., large-scale piñon–juniper or sagebrush removal, clear-cutting of forests, "managed" forests, intense grazing or inundation of riparian woodlands) *	existing or planned	—	—	none	various sources	

[1]Recent genetic work has shown greater genetic divergence between some populations of *M. thysanodes* than between this species and *M. evotis* in some places, and some individuals morphologically identifiable as 1 of these species are genetically assignable to the other species. Further work is needed to resolve these paradoxes.

[2]This species occurs in western North America west of the Great Plains, from British Columbia to southernmost México, but its occurrence may be patchy or localized within this great area. Although little concerning its ecology in México has been reported, within its range north of México it is found in nearly all habitats that are ≤9,350 ft elevation. It also utilizes a wide variety of roosts including buildings, mines, caves, rock crevices, trees (snags), and bridges. Thus it may be considered an ecological generalist. **This table is intended for use north of México**.

[3]It has been asserted that oak, piñon, and/or juniper woodlands (O'Farrell and Studier 1980, Barbour and Davis 1969) and desert scrub (Barbour and Davis 1969) are the plant associations most commonly used by *M. thysanodes*. However, it is questionable whether this species actually shows strong habitat preferences. In 2 Utah studies, in which many sites were sampled and large numbers of bats were captured, relatively few *M. thysanodes* were found in piñon–juniper habitat, and the majority (64% and 56%) were captured in desert scrub situations (see Oliver 2000). This species also has often been captured in sagebrush and in a variety of coniferous forests in Utah and elsewhere. Hoffmeister (1986), discussing this species in Arizona, stated: "Fringed myotis are found from chaparral to ponderosa

pine, but the preferred habitat is probably the oak woodland, from which they forage out into a variety of other habitats." Nagorsen and Brigham (1993, p 93; also Table 1, p 40) wrote of this species: "The British Columbian population is associated with arid grassland and Ponderosa Pine - Douglas-fir forest." Findley et al. (1975), writing of it in New Mexico, noted that it occurs from grassland and desert situations to yellow (= ponderosa) pine forest. Of 84 individuals of this species that Jones (1965) captured in the Mogollon Mountains area of New Mexico and Arizona, 95.3% were in montane coniferous forest (above 7,000 ft elevation), 4.7% were in piñon–juniper–oak woodland (mostly between 5,000 and 7,000 ft elevation), and none were in desert scrub–grassland (below 6,000 ft elevation). Thus, the assertions of some authors concerning its main or preferred habitats as well as the "ratings" of plant associations in this table are questionable, and this species should be considered a habitat generalist, though patchy in its occurrence.

*Most important indicators.

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gvo

hoary bat (*Lasiurus cinereus*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	roosts	trees*	absence of trees	piñon–juniper woodland	presence of small, broad-leafed species; presence of tall conifers (e.g., montane coniferous forest)	presence of tall, broad-leafed species such as cottonwoods (e.g., mature, riverine gallery forests), aspens (e.g., montane forests), and large “street” trees (e.g., elms, maples, lindens, etc., in urban areas)	various sources	This is a tree- and foliage-roosting species. Broad-leafed species are preferred.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat, thermal biology	elevation (Utah) (see Comments)	>9,200 ft (see Comments)	—	<4,000 ft or 8,000–9,200 ft	4,000–8,000 ft	Oliver (2000), Day (personal observations, 2007)	In Hawaiʻi this species (but not the same subspecies as on the mainland of the Americas) is known to occur from sea level to 13,200 ft elevation, mostly below 4,000 ft. Although the highest reported elevation in Utah is 9,200 ft, it is possible that the species may occur as high as tree line (~11,000 ft in Utah).
condition	loss of roosts, foraging habitat	destruction or degradation riparian habitat, including phreatophyte control along desert streams	occurring (past, present, future)	—	—	none		

[1]This species is the most widespread of all American bats (Barbour and Davis 1969), occurring from n. Canada to Argentina and Chile, and in the Hawaiian Islands (considered a distinct, endemic race), and it is known to wander to other areas (e.g., Iceland and the Orkney Islands). It is an ecological generalist, and in Utah it has been found in a wide variety of habitats, from desert shrub to montane forest, and in cities and towns in addition to natural landscapes (Oliver 2000).

*Most important indicator.

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gvo

little brown myotis (*Myotis lucifugus*) Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
size	population	density (uncertain—see Comments)	—	—	—	≥26 individuals /mi^2	Barbour and Davis (1969)	In a “favored” area in New England, the estimated summer population density was 26 individuals /mi^2 (source cited by Barbour and Davis 1969). It is not known how this compares with densities elsewhere, such as in Utah.
landscape	habitat	general habitat (“cover type”) in Utah*	desert scrub, alpine tundra	piñon–juniper woodland, sagebrush steppe, grassland	subalpine shrubland (but see comment concerning elevation, below)	forests, riparian areas, urban areas	Oliver (2000) and other sources	
landscape	natal and nursery sites (maternity and nursery roosts)	available roost structures[2,*]	other	caves (if geothermally warm), beneath tar paper, siding, shingles	bridges, hollow trees, other natural cavities	buildings (especially hot attics)	Barbour and Davis (1969), Fenton and Barclay (1980), Oliver (2000)	
condition	fetal and neonatal development	temper-atures in maternity and nursery roosts*	<30 °C or >55 °C	—	—	30–55 °C	Nagorsen and Brigham (1993)	

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	suitability of natal and nursery sites (maternity and nursery roosts), foraging	proximity to water (e.g., stream, lake)[2,*] see Comments	far (>1 km)	—	—	near (≤1 km)	Barbour and Davis (1969)	"Colonies are usually near a lake or stream; the bats seem to prefer to forage over water" (Barbour and Davis 1969). "In all areas studied, *M. lucifugus* prey heavily on aquatic insects" (Fenton and Barclay 1980). The qualitative term "near" was not defined by Barbour and Davis (1969) and has been arbitrarily considered to be ≤1 km in the ratings. Also, whether this species is as closely associated with water in Utah as it is in e. America is uncertain.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	hibernation	hibernacula (unknown in Utah, see Comments and footnotes 2 and 3)	other (e.g., buildings)	—	—	caves, abandoned mines (elsewhere but not in Utah)	Barbour and Davis (1969), Fenton and Barclay (1980)	Buildings apparently are not used as hibernacula (Barbour and Davis 1969, Fenton and Barclay 1980). Winter habits in Utah are not known, caves and mines evidently are not used as hibernacula in Utah, and even whether this species remains in Utah through the winter or migrates out of the state is unknown (Oliver 2000).
condition	hibernation, winter survival	humidity within hibern-aculum	<70%	70–80%	80–90%	90–100%	Barbour and Davis (1969), Fenton and Barclay (1980), Nagorsen and Brigham (1993)	See footnotes 2 and 3.
condition	diurnal retreats	day roosts	—	caves	trees, rock crevices, under rocks, spaces in piles of wood or lumber	buildings	Barbour and Davis (1969), Fenton and Barclay (1980), Oliver (2000)	"Little brown bats commonly use day roosts with southwestern exposures which provide exogenous heat for arousal from daily torpor . . ." (Fenton and Barclay citing another source)

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	foraging habitat	landscape features*	dense forest, arid habitats	—	open forest, lawns, pastures, tree-lined streets	water (e.g., streams, lakes) and associated willows, aspen stands	Barbour and Davis (1969) and other sources	
landscape	habitat, thermal ecology	elevation (Utah) (see Comments)	<4,300 ft or >10,000 ft	8,100–10,000 ft	6,200–8,100 ft	4,300–6,200 ft	Oliver (2000)	This species occurs at low elevations (including sea level) elsewhere. Females are scarce, and reproductive females usually absent, at higher elevations (e.g., mountains). Ratings ("fair" through "very good") are interpolations based on the known elevational range in Utah.
condition	mortality	pesticide use	none	—	—	occurring in vicinity	Fenton and Barclay (1980)[4]	
condition	mortality	eradication from buildings ("pest control")	none	—	—	occurring	Fenton and Barclay (1980)[4]	

[1]This species is very widely distributed in North America, and its ecology differs in different parts of its great range. This table is intended for use primarily in Utah and adjacent parts of interior western North America. Disturbance of hibernacula, vandalism of colonies, persecution, and scientific collecting have been mentioned as threats to this species by various authors (e.g., Fenton and Barclay 1980; see also Thomas 1995). These threats are intuitive and likely apply to most bats in Utah. Whether they are of more importance to this species than to others is questionable.

[2]It has been suggested that abundance in this species is “related to water and availability of hibernation sites” (Barbour and Davis 1969) and that its “populations are limited by the availability of roosts, rather than by food” (Fenton and Barclay 1980).

[3]In eastern North America, *M. lucifugus* hibernates during winter, but in Utah and most other places in western North America its winter habits are unknown (Barbour and Davis 1969, Oliver 2000). Because bats of the genus *Myotis* (which is worldwide in occurrence) in temperate parts of the world, such as North America, typically hibernate in winter rather than migrate, and because *M. lucifugus* is known to hibernate in eastern North America, it has been assumed that it also hibernates in areas where its winter habits are not known (e.g., Utah). If so, it must hibernate in situations unlike those that it is known to use in eastern North America (caves and mines) and these unknown sites must be rather inaccessible. Although temperatures suitable for hibernation have been reported (Barbour and Davis 1969, Fenton and Barclay 1980, Nagorsen and Brigham 1993), this ecological information has not been included in this table because the application of such information in Utah is not currently possible.

[4]Fenton and Barclay (1980) commented: “Populations of *M. lucifugus* have drastically declined in numbers in many parts of its range, attributable in part to the use of pesticides (whether directly or indirectly applied), control measures in nursery colonies, collecting of bats for experimentation, and disturbance of hibernating individuals.”

*Most important indicators.

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Thomas, D. W. 1995. Hibernating bats are sensitive to nontactile human disturbance. *Journal of Mammalogy* 76: 940–946.

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long-eared myotis (*Myotis evotis*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	plant association (Utah)[1,*]	other (e.g., desert scrub)	spruce forest	aspen forest, mixed forest, ponderosa pine forest, meadows, grassy areas	riparian (willow, tamarisk), sagebrush, piñon–juniper woodland	Oliver (2000)	See footnote 1.
landscape	habitat, thermal biology	elevation (Utah)[1,*] (see Comments)	<4,700 ft or >9,500 ft	4,700–5,000 ft or 8,000–9,500 ft	5,000–6,000 ft or 7,000–8,000 ft	6,000–7,000 ft	Oliver (2000)	Elevations inhabited in Utah range 4,700–9,500 ft (Oliver 2000). Ratings ("fair" to "very good") are estimates within this elevational range. In other parts of its geographic range, this species inhabits lower elevations (including sea level) or prefers some of the higher elevations indicated here (7,000–9,000 ft) (see footnote 1).

[1]This species occurs throughout much of western America and southwestern Canada (and possibly the Baja California peninsula of México). Its ecology varies greatly within this range. In New Mexico and Arizona this species inhabits only montane coniferous forest (e.g., ponderosa pine forest and spruce–fir forest) and does not occur in other habitats at lower elevations (Jones 1965, Findley et al. 1975, Hoffmeister 1986). In British Columbia it is found in many habitats (including grasslands and various forest types) at low to middle elevations (Nagorsen and Brigham 1993), and it occurs near sea level in that province and along the Pacific coast of America. Most Utah records of this species are from piñon–juniper–sagebrush although it also inhabits montane forests in Utah (Oliver 2000). Combining the great geographic differences in its ecology in a single table such as this one would give the false impression that it is an ecological generalist throughout its range when in fact it is an ecological specialist in some places. **This table is intended for use in Utah** and may have very limited applicability elsewhere. The

winter habits of this species are almost completely unknown. Because species of *Myotis* in temperate regions typically hibernate during winter rather than migrate, it has been speculated that this species also hibernates (see discussion in Oliver 2000). Barbour and Davis (1969) commented: “Although *M. evotis* is widespread and not uncommon, very little is known of its habits.” Reported roosts (diurnal, maternity) include almost all possibilities except foliage roosting: buildings, caves, mines, in cracks, cavities, or under exfoliating bark of trees (especially snags), crevices in rocks on ground and in cliffs (Manning and Jones 1989, Rabe et al. 1998, Oliver 2000). Rabe et al. (1998), working in n. Arizona, found: “Long-eared myotis were observed roosting in 5 different roost types: 24 in ponderosa [pine] snag roosts, 14 in cracks in rocks on the ground, 2 in down logs, 2 in Gambel oak tree cavities, and 2 in Gambel oak snags.”
*Most important indicators.

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gvo

long-legged myotis (*Myotis volans*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
size	population	mean no. of ultrasonic call detections (“passes”) per 100-min sample	<0.05	0.05–0.33	0.34–1.00	>1.00	Thomas (1988)	Thomas’ (1988) work was in forests in Oregon. Whether his results are applicable in habitats available to this species in Utah is uncertain.
landscape	maternity and nursery roosts	feature or structure*	caves, mines	—	buildings, rock crevices	trees (under bark, in crevices), especially snags	Barbour and Davis (1969)	Snags—especially large-diameter, tall snags—have been found to be preferred day roosts for this species in Oregon and in Arizona (Ormsbee and McComb 1998, Rabe et al. 1998). It is likely that they also provide preferred maternity roosts.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	plant association *	—	—	woodland (oak, juniper, piñon), sagebrush	montane forests (e.g., aspen, Douglas-fir, ponderosa pine, lodgepole pine, spruce), forest openings	Oliver (2000), Barbour and Davis (1969), Jones (1965)	Thomas (1988) detected much higher foraging activity by this species in old growth (>200 y old) forests than in mature (100–165 y old) and young (<75 y old) forests in Oregon.
landscape	habitat, thermal biology	elevation (Utah)*	<3,150 ft or >10,500 ft	3,150–3,900 ft or 9,900–10,500 ft	3,900–6,500 ft	6,500–9,900 ft	Oliver (2000), Warner and Czaplewski (1984), Barbour and Davis (1969)	Elevational extremes from throughout the range of this species are sea level (Canada) to 12,500 ft (México). However, it “is usually found from 2,000 to 3,000 m [6,562 to 9,842 ft]” (Warner and Czaplewski 1984).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	mortality, reduced reproduction	pesticide use	occurring (recent past, present, or future)	—	—	none (recent past, present, or future)	Henny et al. (1982), other sources	This species shows much greater susceptibility to pesticides than do other bats with which it occurs. After spraying of pesticides to control larvae of Douglas-fir tussock moths in Oregon, this was 1 of the 2 bat species that had the highest pesticide residue levels, and, unlike other bats, its pesticide residue levels remained significantly high for 3 years after spraying (Henny et al. 1982).

[1]This species occurs throughout most of western North America from extreme se. Alaska to central México, and its ecology differs in different portions of its range. **This table is intended for use in Utah**. The winter habits of this bat are unknown in Utah, although it has been reported to hibernate in caves and mines elsewhere.

*Most important indicators.

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pallid bat (*Antrozous pallidus*) Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat, thermal biology	elevation*	>8,700 ft	7,000–8,700 ft	6,000–7,000 ft	<6,000 ft	Oliver (2000), Barbour and Davis (1969)	Writing of this species rangewide, Hermanson and O'Shea (1983), citing others, stated that it has "been collected at sites ranging up to 2,440 m [8,005 ft]". Reported elevations of capture in Utah are 2,700 to 8,700 ft (Oliver 2000). Acoustic detection as high as 10,500 ft has also been reported in Utah (see Oliver 2000), but confirmation by capture of this species at such high elevation would be desirable. Barbour and Davis (1969), writing of this species, noted: "It becomes scarce and local above 6,000 ft."

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	plant association (Utah)*	alpine tundra	mountain meadow, montane forest	piñon, juniper, sagebrush	desert shrub	Oliver (2000)	Findley et al. (1975) in New Mexico found this species to be common in desert and grassland but also captured it in ponderosa pine forest. Although Jones (1965), in the Mogollon Mountains (NM and AZ), found 45.2% of *A. pallidus* in desert scrub–grassland, 37.4% in piñon–juniper–oak woodland, and 17.4% in montane evergreen forest, Hoffmeister (1986) commented that the frequency of captures known to him in evergreen forest in Arizona was lower. In Utah this bat is very scarce in montane forests (Oliver 2000), and in Colorado (Armstrong 1972) and Oregon (Verts and Carraway 1998) it apparently is very rare or unknown in such habitat.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	roost use	disturbance of roosts (see Comments)	occurring or suspected	—	—	none	various authors including Barbour and Davis (1969)	Barbour and Davis (1969) commented of this species: “They are intolerant of disturbance and may abandon a roost when molested, not to return for years.” This species roosts in a wide variety of situations, both natural and man-made. The highly developed social behavior of this species is especially apparent in roosts (e.g., see discussion in Hermanson and O’Shea 1983). This suggests that roosts are especially important to this species, and disturbance of roosts leading to their abandonment may have negative consequences for local populations.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	mortality	vandalism of roosts, extermin-ation at roosts, scientific collecting	occurring or suspected	—	—	none	Hermanson and O'Shea (1983) and sources cited therein	Hermanson and O'Shea (1983) noted that "known sources of mortality include slaughter by vandals . . ., extermination in buildings, and specimen collecting at roosts and watering places." They also noted that predation on this species by raptors, when pallid bats were released by bat researchers during the day, has been reported.

[1]This species occurs from s. British Columbia to c. México (Jalisco and Querétaro), east to w. Kansas, w. Oklahoma, and w. Texas, and in Cuba (though extremely rare, if extant, on this island, where apparently only 2 "whole" specimens, other than fossil and subfossil remains, are known). **This table is intended for use mainly in Utah** but may be applicable in some similar arid areas, especially some adjacent states; it would have very limited applicability in some other areas, such as some coastal areas (Pacific Ocean and Gulf of Mexico), some areas east of the continental divide (e.g., the Great Plains), and Cuba. Although various authors have mentioned that this bat is commonly associated with rocky outcrops near water, rocky situations and water are not requisites. Findley et al. (1975) reported this species in New Mexico "in deserts and grasslands even in the absence of rocky terrain or water." Further, Geluso (1975) determined experimentally that 50% of tested individuals could derive enough water from a mealworm diet to survive and maintain a positive water balance for at least a month when deprived of any drinking water. Comparing its urine-concentrating ability with those of 10 other insectivorous bat species (mostly from New Mexico), including well-known desert-dwelling species, Geluso (1978) found *A. pallidus* to be surpassed by only 1.

*Most important indicators.

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silver-haired bat (*Lasionycteris noctivagans*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	plant association[2]	—	shrub steppe (sagebrush), desert shrub, perhaps grasslands	woodland (e.g., riparian cottonwood, piñon–juniper)	forest (e.g., coniferous, aspen), montane meadow	Oliver (2000) and various other sources	See footnote 2.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat, thermal biology	elevation (Utah) (see Comments)	>10,500 ft	<3,500 ft or 9,760–10,500 ft (uncertain)	3,500–7,000 ft	7,000– 9,760 ft	see Comments	Ratings are uncertain and in part are based on the ecology of this species elsewhere; e.g., Findley et al. (1975) wrote: “Silver-haired bats have been taken at most elevations in New Mexico, but during the summer they are usually found high in the mountains.” The reported Utah elevational range of this species is ~2,500 ft to 9,760 ft (Oliver 2000). However, it is likely that it may occur as high as tree line (~10,500–11,000 ft in most places in Utah). In Utah forests typically are present between ~7,000 and 10,500 ft, woodlands between ~3,500 and 7,000 ft, and desert shrub below ~3,500 ft (see indicator above).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	loss of habitat, day roosts[3], maternity roosts	timber harvest, forest manage-ment (especially removal of snags)* also: elimination of woodlands (e.g., piñon–juniper, riparian cotton-wood)	occurring (past, present, future) few or no snags	—	—	none (past, present, future) abundant snags of varying ages and states of decay	Kunz (1982), Nagorsen and Brigham (1993), Campbell et al. (1996)[3]	Although Kunz (1982) noted the paucity of roosting data for this species (i.e., at the time of his writing), he commented: “Assuming that tree-roosting is the preferred habit, extensive deforestation and forest management practices over the last two centuries may have reduced the roosting sites available.” Likewise, Nagorsen and Brigham (1993) considered it “a species that may be especially vulnerable to deforestation and the removal of snags.” (See footnote 3.)

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	mortality, impaired reproduction	pesticide use	occurring	—	—	none	Henny et al. (1982)	*L. noctivagans* was 1 of the bat species that exhibited an increase in pesticide residues after spraying of DDT to control Douglas-fir tussock moths in forests in ne. Oregon (Henny et al. 1982).

[1]This species ranges from se. Alaska and se. Canada to ne. México (Tamaulipas). **This table is intended for use mainly in Utah and some neighboring areas**, and it may have limited applicability in other parts of the range of *L. noctivagans* (e.g., e. Canada and e. America, prairie provinces and plains states, the Pacific coastal region, México).

[2]*L. noctivagans* occurs in nearly all habitats (plant associations) that exist in Utah and has been found in towns and cities in this state (Oliver 2000). However, this species is migratory, and some of the habitats in which it has been captured in Utah may be used only in migration. Elsewhere *L. noctivagans* also occurs in a wide variety of habitats, including grasslands (e.g., Nagorsen and Brigham 1993), but it is considered mainly a bat of forests, both coniferous and deciduous, in some places reaching highest densities in old-growth forests (e.g., Thomas 1988). Writing of this species in Arizona, Hoffmeister (1986) commented: "Silver-haired bats in summer are encountered most often over mountain meadows surrounded by conifers, especially Douglas-fir, spruce, white fir, and aspen." However, Hoffmeister (1986) also noted captures in a low-elevation riparian setting among cottonwoods.

[3]Campbell et al. (1996) studying roosting of this species in coniferous forests in ne. Washington, found that it roosted in dead or dying trees (1) with exfoliating bark, extensive vertical cracks, or cavities, (2) with dbh >30 cm, (3) 6.9–61.5 m tall, and (4) <3.5 km from water where the bats were captured. Roosts were 6.1–15.2 m above ground. Roost trees were significantly taller than neighboring trees, and within 15 m of the roost trees there was significantly less closure of he overstory canopy, less understory, and shorter understory vegetation than in comparable random plots. Although these findings (and those of Thomas 1988 in Washington and Oregon) have implications for *L. noctivagans* in Utah, they are not incorporated (above) in this table because of dissimilarities between the forests studied in Washington and those that exist in Utah (e.g., tree species and sizes, and perhaps stand ages and densities). The data do suggest that, where available in Utah, *L. noctivagans* may preferentially roost in large dead or dying trees with cavities, cracks, or exfoliating bark.

*Most important indicator.

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spotted bat (*Euderma maculatum*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	habitat	roosts* (see Comments)	—	caves	—	rocky situations (e.g., rock crevices in cliffs)	various authors	Roosts are poorly known and incompletely understood. This species has been found in caves and cave-like situations several times but generally is not considered to be a cave-roosting species. However, the only reported observation of hibernation was in a cave in Utah. Although some of the sources that have claimed that rock crevices are the main roosts drew this conclusion from flawed experimental approaches (e.g., the release of spotted bats during daylight; see discussion in Oliver 2000), roosting in cliff crevices has been confirmed by reliable methods.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	mortality, injury	capture, handling, collection (science)* (see Comments)	bats killed for specimens or mist nets not continuously monitored or bats released during daylight	no collecting of specimens and mist nets monitored at all times and bats released only at night	none	none	various authors including Fenton et al. (1983), Oliver (2000) and sources cited therein	*E. maculatum* is an especially delicate bat and appears to be much more subject to injury from capture and handling than are other bat species (see Oliver 2000). Mortality of spotted bats in mist nets that are not *continuously* monitored is very high, as is mortality of spotted bats released during daylight, which very commonly are taken by diurnal birds of prey (see Oliver 2000). Severe injuries and death from mist net capture and handling are very common in this species (see Oliver 2000). Fenton et al. (1983) considered scientific collecting to be the greatest threat to this species, which is among the most coveted of all species by collectors of mammals.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	mortality, impairment of reproduction	use of pesticides	occurring in vicinity	—	—	none	Fenton et al. (1983)	

[1]This species occurs throughout most of western North America west of the Great Plains, from British Columbia to central México, and from below sea level to almost 10,000 ft elevation. Within its elevational and geographic range, it inhabits most (perhaps all) habitats from low desert situations and lowland marshes associated with lakes to montane coniferous forests, and it has been found in agricultural areas and occasionally in towns and cities. Some earlier authors suggested that *E. maculatum* is a bat of higher elevations that may move to lower elevations in cooler months. Several later authors have speculated that *E. maculatum* prefers low elevations and only makes seasonal movements to higher elevations when temperatures become unbearable at low elevations in summer. However, the latter hypothesis is unlikely for at least 2 reasons. Most other western North American bats, including all of the closest relatives of this species, are quite tolerant of high ambient temperatures. More importantly, lactating females of this species have been captured at some of the highest known locations for *E. maculatum*, and high elevations must be considered important maternity habitats for it, just as low elevations are known to be. Existing evidence indicates that *E. maculatum* exhibits no elevational preference in most of its distributional range. Although its wintering habits are poorly known, the spotted bat has been found hibernating in a cave (once) and has been captured in mist nets on several occasions during winter when temperatures were well below freezing (as low as –5 °C) (see Oliver 2000). Because of the elusive nature of this species, many aspects of its biology remain poorly understood relative to other North American bats. Various authors have claimed insights into its ecology, but some of these have been based on unreliable methods (see Oliver 1997, 2000) and most others appear to be of only local rather than general application. Aspects of its ecology reported thus far suggest that, despite its being a difficult species to study, it is an extreme generalist. There may in fact be only 1 other bat species (*Eptesicus fuscus*, the big brown bat) in western North America that is as great a generalist as *E. maculatum*. Other than capture, handling, and collecting for scientific purposes, threats to this species are unknown. Generalizations from knowledge of threats to other bat species could be made.

*Most important indicators.

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Townsend's big-eared bat (*Corynorhinus townsendii*)[1]
Ecological Integrity Table[2]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
size	population density	no. of individuals per hectare	≤0.007/ha	0.008–0.016	0.016–0.024	≥0.025/ha	Pearson et al. (1952), Humphrey and Kunz (1976)	This species "seems to be nowhere abundant" (Barbour and Davis 1969). Humphrey and Kunz (1976) estimated a population density of 1 bat per 40 ha in an area on the Great Plains (Oklahoma and Kansas) (misstated as "one bat per ha" by Kunz and Martin 1982). Pearson et al. (1952) estimated 1 bat per 310 acres (126 ha) and 1 bat per 419 acres (170 ha) in 2 places in California but considered these to be the lower limit of densities and probably underestimates. **N.B.**: "Ratings" should be considered uncertain since they are based on few data and estimates.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	shelter, reproduction, hibernation, thermal ecology	roosts (including maternity colonies[3], day roosts, hibern-acula)*	other (e.g., bridges, culverts) (tree hollows and rock crevices are used in some places that lack caves and mines, but such roost sites are not generally preferred)	buildings (e.g., abandoned buildings, attics, cellars)	abandoned mines	caves	Sherwin et al. (2000, 2003) and other sources including Barbour and Davis (1969), Kunz and Martin (1982), Pierson et al. (1999), Oliver (2000)	Although Sherwin et al. (2000) found that "[i]n general, roosts with single low (<1.5 m) entrances were more likely to be occupied than those with multiple or tall entrances . . .[,] maternity colonies tended to be located in large complex sites with multiple openings." They warned: "At the landscape level, predictions can be made regarding likelihood of presence of *C. townsendii*. However, the perception that individual sites within a habitat of choice can be identified as roosts based on easily selected and measured variables is false", and it is ". . . difficult, if not impossible, to quickly assess the value of potential roosts." (See also footnotes 3 and 4)

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	hibernation	winter temper-atures in roosts used as hibernacula *	>55 °F (>13 °C) or <28.5 °F (<–2 °C)	50–55 °F (10–13 °C)	28.5–33 °F (–2–0.5 °C)	33–50 °F (0.5–10 °C)	Pearson et al. (1952), Barbour and Davis (1969), Kunz and Martin (1982), Nagorsen and Brigham (1993), Pierson et al. (1999) and sources cited therein	Only part(s) of the roost need to satisfy the indicated thermal requirements at any given time, and the bats will move as thermal conditions shift within the roost. Ideal temperatures probably are at or near the low end of the "very good" range. (Survivable minimum temperatures may actually be lower than those indicated, for hibernation has been reported at temperatures as low as –4 °C and –7 °C in British Columbia [Nagorsen and Brigham 1993].)
condition	habitat	summer temper-atures in maternity roosts	>30 °C or <19 °C	—	—	19–30 °C	Pierson et al. (1999)	"Recorded temperatures in maternity roosts throughout California vary between 19°C in the cooler regions to 30°C in the warmer southern regions . . ." (Pierson et al. 1999).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	habitat, thermal ecology	elevation* (see Comments)	>2,600 m (>8,530 ft)	2,001–2,600 m (6,565–8,530 ft)	1,701–2,000 m (5,581–6,562 ft)	<1,700 m (<5,577 ft)	Sherwin et al. (2000, 2003)	The work of Sherwin et al. (2000) was in n. Utah in an area that "ranged in elevation from 1,350 to 3,600 m [4,429–11,810 ft]". This species has been reported to occur "from near sea level to well above 3,160 m [10, 367 ft]" (Kunz and Martin 1982), which suggests that there are not many places within its range that would be elevationally completely unsuitable. However, this bat is rarely encountered above ~9,000 ft elevation, at least in America (see Barbour and Davis 1969, also Oliver 2000). Of 263 potentially suitable roosts above 2,600 m (8,530 ft), Sherwin et al. (2000) found only 1 that was occupied. (It is possible that higher elevations are inhabited in México.)

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	habitat	plant association (in inter-mountain west, especially n. Utah[4]) (see Comments)	aspen forest, mixed conifer forest	riparian	sagebrush–grass steppe, mountain brush	juniper woodland	Sherwin et al. (2000)[4]	**N. B.**: Ratings for this indicator are for intermountain w. North America, esp. n. Utah, and should not be applied elsewhere (e.g., Canada, México, Pacific coast, Great Plains, eastern North America). The work of Sherwin et al. (2000) was in n. Utah; thus, many plant associations inhabited by this species elsewhere were not available and were not evaluated. This species also occurs in deserts and prairies and in eastern deciduous forest and other forest types. Sherwin et al. (2000) found that presence of *C. townsendii* was associated with lower elevation and with habitat (plant community), and "[n]o other surface variables were associated with occupancy of a site".

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	health	banding (for scientific research)	occurring	—	—	none	Pearson et al. (1952), Humphrey and Kunz (1976), Kunz and Martin (1982), Verts and Carraway (1998)	Wing bands should not be attached to bats of this species, which responds more negatively to bands than do other temperate zone bat species. Banding of this species frequently causes irritation and inflammation of tissues, sometimes resulting in abnormal bone growth or heavy, persistent infection, especially in females (Humphrey and Kunz 1976). Also, banding of pre-volant young has been known to cause their mothers to move all young to a different roost (Pearson et al. 1952).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	mortality, abandonment of roosts	human disturbance (e.g., recreation-al caving, scientific studies) and vandalism of roosts*	occurring or potentially occurring (e.g., no bat gates)	—	—	none (e.g., suitably designed, vandal-proof bat gates exist)	various sources including Barbour and Davis (1969), Kunz and Martin (1982), Verts and Carraway (1998), Pierson et al. (1999), Oliver (2000), Sherwin et al. (2000, 2003)	*C. townsendii* is particularly sensitive to disturbance. "[S]imply the presence of people cause[s] this species to desert preferred roosts as well as alternate roosts" (Humphrey and Kunz 1976), and "disturbance at roost sites has contributed substantially to population declines" (Pierson et al. 1999, p 27). Caves and abandoned mines used as roosts should be protected from human entry, including scientific monitoring (Verts and Carraway 1998; see also Pierson et al. 1999, pp 22–23, 25–26), e.g., using "bat gates", signs, and enforcement (Pierson et al. 1999).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	poisoning (mortality), reduction in prey base	pesticide use	occurring within 3 mi (5 km)	none within 8 mi (13 km)	none within 20 mi (32 km)	none within 40 mi (64 km)	Pierson et al. (1999)	“Ratings” are estimates based on greatest reported distances moved by this species (32 and 64.4 km) and reported foraging distances (up to 5 and 13 km) (see Kunz and Martin 1982, Pierson et al. 1999, pp 3, 6, 27). However, recent, unpublished work suggests that foraging distances may be much greater than have been reported (>150 km in a single night), so the “ratings” are likely quite conservative.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	mortality	toxic material ponds (sulfuric acid ponds resulting from mining; cyanide used in mining; oil reserve pits)	existing within 3 mi (5 km)	none within 8 mi (13 km)	none within 20 mi (32 km)	none within 40 mi (64 km)	Pierson et al. (1999, p 24)	"Ratings" are estimates based on greatest reported distances moved by this species (32 and 64.4 km) and reported foraging distances (up to 5 and 13 km) (see Kunz and Martin 1982, Pierson et al. 1999, pp 3, 6, 27). However, recent, unpublished work suggests that foraging distances may be much greater than have been reported (>150 km in a single night), so the "ratings" are likely quite conservative. "This problem may be particularly severe in desert areas, where water associated with mining operations may be the only water in an area" (Pierson et al. 1999).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	conversion of natural habitats (e.g., to agriculture)	occurring (past, present, or future)	—	—	none	Pierson et al. (1999)	Some preferred habitats of this species in w. North America—piñon–juniper woodland and sagebrush steppe—are subject to widespread conversion for agriculture and grazing.
landscape	loss of foraging habitat and prey base	livestock grazing	occurring	—	—	none	Pierson et al. (1999)	"Livestock grazing practices have been responsible for large-scale conversions of mesic riparian habitats to more xeric . . . habitats across the range of *C. townsendii*" (Pierson et al. 1999).

[1]Although most mammalogists currently assign this species to the genus *Corynorhinus*, some place it in the genus *Plecotus* (see Oliver 2000 for discussion).

[2]This species occurs mainly in western North America, where it ranges from British Columbia to Oaxaca, but a few disjunct populations also occur in eastern America (as far east as West Virginia and Virginia). **This table is intended for use mainly in western America, especially the intermountain west; the indicator "plant association" should be applied *only* in the intermountain west and is recommended only in n. Utah and similar areas.** Most of the other indicators, however, can be used throughout the range of this species.

[3]Pierson et al. (1999) asserted: "*C. townsendii* . . . requires a relatively spacious roost. The majority of the roosts examined in California . . . are at least 30 m in length, with the roosting area located at least 2 m above the ground [i.e., the cave or mine floor]. Maternity clusters are often located in ceiling pockets or along the walls just inside the roost entrance, within the twilight zone."

[4]Sherwin et al. (2003) cautioned: "[M]odels of roost selection [of *C. townsendii*] generated by Sherwin et al. (2000 . . .) for northern Utah were not applicable beyond the local scale. In fact, the use and application of locally derived models of roost selection across the range of this species to predict suitability of roosts could have disastrous results as incorrect types of roosts would be selected for protection."

*Most important indicators.

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western pipistrelle (*Parastrellus hesperus*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	plant associ-ation*	alpine tundra	montane forest, mountain meadow	piñon–juniper woodland, sagebrush, mountain brush	desert shrub and desert riparian, arid grassland	Oliver (2000), Findley et al. (1975), other sources	Findley et al. (1975), writing of this species in New Mexico, reported: "Of the specimens that we have collected, approximately 63 percent came from grassland and desert, 35 percent came from woodland (piñon–juniper and oak encinal), and 2 percent came from the yellow [= ponderosa] pine zone." However, Hoffmeister (1986) in Arizona stated: "They fly over the mesquite–creosote bush deserts, among the [riparian] cottonwoods and sycamores, over the palo verde and saguaro, over the pinyon-juniper, to the fir-spruce of the highest mountains."

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat, thermal biology	elevation (Utah)*	>8,710 ft	6,500–8,710 ft	3,500–6,500 ft	<3,500 ft	Oliver (2000), Barbour and Davis (1969)	Sidner (1999) wrote of this species (rangewide): "It occurs from near sea level to 2,825 m [9,268 ft] elevation . . . ." Elevations of reported capture of this bat in Utah range 2,600–8,710 ft (Oliver 2000). However, acoustic detection of this species at 10,560 ft in Utah has been reported (see Oliver 2000). Although this seems consistent with the comments of Hoffmeister (1986) for Arizona (see quote above), confirmation of the occurrence of this species at such high elevation in Utah based on capture would be desirable (Oliver 2000), and this species is certainly quite rare at high elevations in Utah and elsewhere.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	roosts	physio-graphy[2]	—	flat, rockless areas	some slope, some rockiness	rocky areas (canyons, cliffs, rocky slopes and outcrops)	Hoffmeister (1986), Sidner (1999)	**See footnote 2**.

[1]This species occurs from se. Washington and sw. Oklahoma to s. México, mainly in the American southwest and in n. and w. México. **This table is intended for use mainly in Utah**. Anthropogenic threats to this species are not known but presumably include those that are believed to affect most bats—e.g., pesticides and alteration, degradation, and destruction of natural habitats. Although *P. hesperus* does not appear to be favored by human activities (as some bat species may be, particularly those species that preferentially roost in buildings, mines, or palms and those that may preferentially forage in cities or in certain agricultural settings such as orchards), it is the most abundant bat in many places, and most of the places that it inhabits have thus far remained largely unspoiled by human activities. O'Farrell and Bradley (1970), who mist-netted a single spring at 4,460 ft elevation in s. Nevada for 70 nights, in all months, over a 4½ year period, found *P. hesperus* to be by far the most abundant of the 8 bat species that they captured—even though, as Barbour and Davis (1969) pointed out, "they are not captured in proportion to their numbers . . . [f]or each one that is caught many others will be seen to turn away from the net." Despite this, *P. hesperus* accounted for 75% (648) of all 865 bats that O'Farrell and Bradley (1970) captured; i.e., it was 1.5 times as abundant as all 7 other bat species combined, or 6.0 times more abundant than expected if all 8 species had been equal in abundance. Based on reported records of bats in Utah, Oliver (2000) called it "this state's most abundant bat."

[2]Although some authors (e.g., Hoffmeister 1986, Sidner 1999) have noted the affinity of this bat for canyons, cliffs, and rocky outcrops, *P. hesperus* certainly is not limited to such areas and in fact is less dependent upon rocky situations than are other bats of the American deserts. As Barbour and Davis (1969) pointed out: "Over vast areas of flat desert covered almost exclusively with creosote bush (*Larrea*) *P. hesperus* may be the only bat. . . . We have seen them appear over the desert in early evening 20 miles or more from the nearest rocky outcrop and nearly as far from any tree or building." Some authors (e.g., Sidner 1999) have further suggested that *P. hesperus* requires proximity to permanent surface water. Sidner (1999) declared "It roosts . . . near permanent sources of water . . ." and referred to it as "always being found near a source of water." This claim is untrue. The same desert flats where *P. hesperus* may be the only bat—20 miles from the nearest rocky outcrop, tree, or building—may also be devoid of permanent surface water for similar distances. Moreover, even when experimentally deprived of *any* drinking water for 1½ weeks in captivity, *P. hesperus* continued to eat well and to maintain weight and was able to maintain a positive water balance, which only 1 of the 10 other bat species tested (almost all from New Mexico, a few from Arizona and w. Oklahoma) could do, namely *Antrozous pallidus*, and the urine-concentrating ability of *P. hesperus* surpassed that of all 10 other bat species tested, including *A. pallidus* (Geluso 1978). Thus, both field observation and laboratory experimentation indicate that proximity to water is of less importance to *P. hesperus* than to other species of insectivorous North American bats, including well-known desert-dwelling species.

*Most important indicators.

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western red bat (*Lasiurus blossevillii*)[1]
Ecological Integrity Table[2]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	setting*	other	—	towns and cities	riparian situations	Oliver (2000)	
condition	habitat (roosting and foraging)	plant association *	other	coniferous forest (e.g., pine-fir)	oak woodland, cultivated orchards (fruit and nut trees)	riparian deciduous woodland (e.g., sycamore, cottonwood, walnut, oak)	various sources including Findley et al. (1975), Hoffmeister (1986), Nagorsen and Brigham (1993)	Suitable riparian situations include desert riparian areas.
condition	roosts	habitat features*	other	mines and caves	shrubs, vines	trees	various sources	Preferred roosts are likely higher (e.g., trees), in plants with large leaves (e.g., sycamores, figs, grapes, sunflowers), and within dense foliage. Although this is a foliage-roosting species, caves and mines are occasionally used (see Oliver 2000).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat, thermal ecology	elevation (in America)	≥7,000 ft (uncertain)	—	—	<7,000 ft	Oliver (2000)	Although elevation has rarely been reported, apparently the highest in America is 6,760 ft (Oliver 2000). Most known elevations in America are much lower (e.g., Nagorsen and Brigham 1993).
landscape	habitat loss (roosting and foraging)	loss of riparian areas (conversion to agriculture, reservoirs, etc.)*	existing or planned	—	—	none	various sources	This species appears to be more dependent upon riparian areas than are most other bats within its range. Thus the loss of or degradation of riparian situations likely would affect it even more than other bat species.
landscape	direct mortality, loss of insect prey	pesticide use (especially in orchards)	existing	—	—	none	various sources	Because this species is known to forage in orchards and in urban residential settings where pesticide use often is especially heavy, it is suspected that pesticides represent even greater danger to it than to other bats.

[1]Not all mammalogists consider this to be a valid species distinct from the “eastern” red bat (i.e., the red bat), *Lasiurus borealis* (see Oliver 2000 for discussion). Despite the questionable validity of this species as distinct from *Lasiurus borealis*, care has been taken in the preparation of this table to separate and use only information specific for *L. blossevillii*.

[2]*Lasiurus blossevillii* has a very broad latitudinal distribution, occurring in temperate and tropical regions of both North America and South America, from British Columbia to Argentina and Chile. **This table is intended for use north of México**.

*Most important indicators.

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western small-footed myotis (*Myotis ciliolabrum*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	hibernacula	structure or feature*	other	—	rock crevices	caves, mines	Oliver (2000), Barbour and Davis (1969), Holloway and Barclay (2001)	Bogan (1999) commented concerning this species: "There appear to be few specific threats to its existence, although closure of abandoned mines could threaten some roosting sites." Oliver (2000) discussed this species, the importance of abandoned mines for its roosts, and mine closures in Utah, noting that "abandoned mines that are used by bats are not closed but rather are gated . . . ."

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat	plant association *	alpine tundra	desert shrub	sagebrush, greasewood, rabbitbrush	montane grassland, woodland, and forest (e.g., ponderosa pine, lodgepole pine, Douglas-fir, aspen), piñon, juniper	Oliver (2000)	Concerning this species west of the plains, Bogan (1999) has written: "[I]t . . . is an inhabitant of rocky areas in yellow [= ponderosa] pine and mixed coniferous forests. . . . Rarely does it occur below the level of ponderosa pine." However, in Arizona it occurs ". . . in a variety of habitats above the hottest deserts among oaks, over chaparral, in riparian situations with junipers and oaks, and the lower edge of the oak belt" (Hoffmeister 1986). In New Mexico "[t]he center of distribution . . . seems to be in the ponderosa pine zone, although [they] occur as low as desert and as high as the lower edges of the spruce-fir zone" (Findley et al. 1975).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	habitat, thermal biology	elevation (Utah)*	<2,950 ft or >8,900 ft	2,950–3,500 ft	3,500–6,500 ft	6,500–8,900 ft	Oliver (2000)	Elsewhere, the reported elevational range for this species is 300–3,300 m (984–10,827 ft) (Holloway and Barclay 2001). The known elevational range of this bat in Utah is 2,950–8,900 ft (Oliver 2000). Bogan (1999) commented that in the west this species rarely occurs below the ponderosa pine zone. In Utah the reported elevational range of ponderosa pine is 5,200–8,809 ft, but well-developed stands or forests of this pine are rare below ~6,500 ft in Utah (Oliver, personal observations).

[1]*Myotis ciliolabrum* (*sensu lato*) is found in w. North America (mainly in interior areas, e. to the w. Great Plains) from sw. Canada to c. México. However, its taxonomy is uncertain and unstable. Some mammalogists in recent years have continued to regard *M. ciliolabrum* as conspecific with *M. leibii* of e. North America. Others, at the other extreme, have split *M. ciliolabrum*, elevating its 2 races to specific status. Under this arrangement, small-footed myotis in Utah are either mostly or entirely *M. melanorhinus*, and the occurrence of *M. ciliolabrum* (*sensu stricto*) in Utah is uncertain. Thus there are 3 possible arrangements and 3 possible specific names for small-footed myotis in Utah, and the small-footed myotis of Utah may represent either 1 or 2 species. The correct name(s) for these bats may be (1) *M. leibii* (*sensu lato*), (2) *M. ciliolabrum* (*sensu lato* or, in part, possibly *sensu stricto*), or (3) *M. melanorhinus*. (See Oliver 2000, pp 45–46, for

discussion of these views and their taxonomic implications for small-footed myotis in Utah.) **This table is intended for use primarily in Utah** and applies mainly to the taxon *melanorhinus*, whether it is considered a race or a species.

*Most important indicators.

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Yuma myotis (*Myotis yumanensis*)
Ecological Integrity Table[1]

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	development of young	maternity or nursery roosts	other	—	bridges, caves, mines	buildings	Barbour and Davis (1969), Oliver (2000), Hoffmeister (1986), Nagorsen and Brigham (1993)	Hoffmeister (1986) commented: "I suspect that only rarely do Yuma myotis occupy mine shafts or caves in Arizona."
landscape	shelter	diurnal roosts	other	—	crevices in cliffs, abandoned cliff swallow nests	mines, buildings, bridges	Oliver (2000), Findley et al. (1975), Hoffmeister (1986)	Hoffmeister (1986) commented: "I suspect that only rarely do Yuma myotis occupy mine shafts or caves in Arizona."
landscape	thermal ecology, habitat	elevation[1,]*	>11,000 ft	9,000–11,000 ft	7,000–9,000 ft	<7,000 ft	Jones (1965), Findley et al. (1975), Oliver (2000)	In the northernmost parts of its range, this species apparently is limited to low elevations (sea level to 2,400 ft) (Nagorsen and Brigham 1993).
landscape	habitat	plant association (n. of México—i.e., America and Canada)*	alpine tundra	ponderosa pine forest, mixed forest, Douglas-fir forest, spruce–fir forest, Pacific coastal forests (e.g., redwoods)	sagebrush, mountain brush	lowland riparian, desert shrub, grassland, piñon–juniper woodland	Jones (1965), Barbour and Davis (1969), Oliver (2000), Findley et al. (1975), Nagorsen and Brigham (1993), other sources	Close proximity to water is required in all habitats.

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
landscape	foraging, water balance (need for drinking water)	proximity to water*	far	—	—	near	Barbour and Davis (1969) and many other sources	"*M. yumanensis* seems to be more closely associated with water than any other North American species of bat" and "nearly all habitats of this bat show a common feature—some open water nearby" (Barbour and Davis 1969). (Actually there are several bat species, from Panamá to México, that are even more closely associated with water than is this species, but the above statement is true north of México, i.e., in America and Canada.) Despite the fact that this species often inhabits very arid situations, its urine-concentrating ability is poor—the poorest of 11 bat species (mainly from New Mexico) experimentally tested by Geluso (1978).

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
condition	reproduction	human disturbance of maternity or nursery colonies	occurring	—	—	none	Dalquest (1947)	

[1]This species occurs in western North America, from British Columbia to w.-c. México. Within this range it is found in a wide variety of habitats, from deserts to montane coniferous forests, and at elevations from sea level to 11,000 ft elevation; however, in nearly all situations it is strongly tied to water (e.g., streams, rivers, ponds, lakes). Many authors have considered this species to be a bat of arid and semi-arid situations and low elevations (but invariably near water), although there are many exceptions to these generalizations concerning aridity and low elevation. Findley et al. (1975) wrote: "In New Mexico the zonal center of abundance of this species seems to be in desert, grassland, and woodland, and the riparian communities of these zones, from 4,000 to 7,000 feet in elevation." Little if anything has been reported concerning the ecology of this species in México. This table is intended for use north of México, primarily in and southwestern and interior western America (especially Utah). The winter habits of *M. yumanensis* are not known (Barbour and Davis 1969 and many other sources) or, at most, very poorly and incompletely known. Species of the genus *Myotis* in temperate regions of the world typically hibernate. However, Howell (1920) believed that bats of this species migrate out of southern California in winter, and Hoffmeister (1986) believed the same about this species in Arizona. However, others (e.g., Dalquest 1947) have speculated that it hibernates. Nagorsen and Brigham (1993) noted that "[i]n coastal Washington a few individuals have been found hibernating in caves . . .", but this species has not been found to hibernate in caves in other places (e.g., Utah, New Mexico, Arizona).

*Most important indicators.

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Appendix 2. Recommendations for addressing white nose syndrome

Recommendations from the Western Bat Working Group for addressing White Nose Syndrome (WNS) in western North America

29 April 2008

In 2007, some 8,000 to 11,000 bats died in several cave hibernacula in the vicinity of Albany, NY—more than half the wintering bat population in those caves. Many of the dead or dying bats had a white fungus on their nose, thus the mysterious disease was dubbed White Nose Syndrome (WNS). In 2008, biologists have documented symptoms associated with WNS in hibernating bats in New York, southwest Vermont, northwest Connecticut, and western Massachusetts.

At least one of the affected species, the Indiana bat, is protected by the US Endangered Species Act. Little brown bats have sustained the largest number of deaths, although northern long-eared, eastern pipistrelle, small-footed myotis and other bat species also have been affected.

Bats with WNS often have a white ring of fungus around their muzzle and their wings or tail membrane. It is not known whether the fungus is causing the deaths or whether it is symptomatic of disease. There is no evidence that people are affected by WNS, but they may transmit the fungus between caves or mines.

To date, there is no documentation of WNS in the West. However, until we have a better understanding of WNS, we ask that anyone entering roost sites, including caves, mines, buildings, bridges, and other structures, take precautions to prevent the possible spread of WNS and be attuned to evidence of WNS. To this end, we provide the following recommendations for the western US, Canada, and Mexico:

- Individuals (such as those from grottos, minerals personnel, bridge engineers, or facilities personnel), who frequent bat-roosting habitat need to be aware of the symptoms (see links at the bottom of this advisory).
- Avoid unnecessary entry to known bat roosts until there is a better understanding of WNS and how it is transmitted.
- Do not enter a western roost site with equipment or clothing that has been exposed to eastern (east of the Mississippi River) roost sites without following a decontamination protocol (see USFWS website: http://www.fws.gov/northeast/whitenosemessage.html#containment).
- If you travel from the west to visit eastern roost sites, particularly caves and mines, take disposable clothing, footwear, and gear that you can discard in the east before returning west to avoid potential transportation of contaminants. Also, avoid contamination of your vehicle by changing

out of clothes used in eastern sites and disposing of or sealing them prior to getting in your vehicle.

- Post information on WNS at popular cave sites and include decontamination requirements for clothing and equipment previously exposed to eastern sites as part of entry permits.
- If WNS is suspected at a roost site, contact your state or provincial wildlife agency or local USFWS office immediately, as well as inform your WBWG State or Provincial Representative (see www.wbwg.org for representative contact information).
- Cavers are critical partners for identifying and monitoring bat roosts associated with caves. Partner with local grottos to collaboratively identify and monitor cave roosts and encourage cavers to keep detailed cave logs.
- Work with your federal, state, and provincial wildlife agency personnel to establish a centralized baseline for roost-site location information Inclusion of sites that are most likely to be entered by people who also have been exposed to eastern roost sites is especially important so that they can be monitored.
- Engage your federal, state, and provincial wildlife agency personnel to establish a legitimate and credible monitoring strategy for roost sites, especially those sites with the highest risk of potential contamination such as popular caving sites that serve as hibernacula. It is important that any monitoring effort is conducted by qualified, trained personnel to avoid inappropriate intrusions on bats that also can cause bat fatalities.

For specific information and current status of WNS, please see the following links:

Western Bat Working Group
www.wbwg.org

National Speleological Society
http://www.caves.org/committee/conservation/WNS/WNS%20Info.htm

U. S. Fish and Wildlife Service
http://www.fws.gov/northeast/white_nose.html

Bat Conservation and Management
http://www.batmanagement.com/cgi-bin/yabb2/YaBB.pl?num=1199773599/0

Appendix 3. Guidelines for wind energy development

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington, D.C. 20240

IN REPLY REFER TO:

MAY 13 2003

FWS/DFPA/BFA

Memorandum

To: Regional Directors, Regions 1-7

From: Deputy Director

Subject: Service Interim Guidance on Avoiding and Minimizing Wildlife Impacts from Wind Turbines

Wind-generated electrical energy is renewable, produces no emissions, and is considered to be generally environmentally friendly technology. Development of wind energy is strongly endorsed by the Secretary of the Interior, as expressed in the Secretary's Renewable Energy on Public Lands Initiative (May 2002). However, wind energy facilities can adversely impact wildlife, especially birds and bats, and their habitats. As more facilities with larger turbines are built, the cumulative effects of this rapidly growing industry may initiate or contribute to the decline of some wildlife populations. The potential harm to these populations from an additional source of mortality makes careful evaluation of proposed facilities essential. Due to local differences in wildlife concentration and movement patterns, habitats, area topography, facility design, and weather, each proposed development site is unique and requires detailed, individual evaluation.

Service personnel may become involved in the review of potential wind energy developments on public lands through National Environmental Policy Act review (sections 1501.6, *opportunity as a cooperating agency*, and section 1503.4, *duty to comment on federally-licensed activities for agencies with jurisdiction by law*, i.e., the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act); or because of special expertise. The National Wildlife Refuge System Improvement Act requires that any activity on Refuge lands be determined to be compatible with the Refuge system mission and Refuge purpose(s). In addition, the Service is required by the Endangered Species Act to assist other Federal agencies in ensuring that any action they authorize, implement, or fund will not jeopardize the continued existence of any federally endangered or threatened species. Service biologists have also received requests from industry for consultation on wildlife impacts of proposed wind energy developments on private lands.

The following guidance was prepared by the Service's Wind Turbine Siting Working Group. It is intended to assist Service staff in providing technical assistance to the wind energy industry to avoid or minimize impacts to wildlife and their habitats through: (1) proper evaluation of potential wind energy development sites; (2) proper location and design of turbines and

associated structures within sites selected for development; and (3) pre- and post-construction research and monitoring to identify and/or assess impacts to wildlife. This guidance is intended for terrestrial applications only; guidelines for wind energy developments in marine environments and the Great Lakes will be provided at a future date. The interim guidelines are based on current science and will be updated as new information becomes available. They will be evaluated over a two-year period, and then modified as necessary based on their performance in the field and on the latest scientific and technical discoveries developed in coordination with industry, states, academic researchers, and other Federal agencies. A Notice of Availability and request for comments will be published in the Federal Register simultaneously with the release of this guidance to Service personnel. We encourage industry use of this guidance and solicit their feedback on its efficacy.

These guidelines are not intended nor shall they be construed to limit or preclude the Service from exercising its authority under any law, statute, or regulation, and to take enforcement action against any individual, company, industry or agency or to relieve any individual, company, industry, or agency of its obligations to comply with any applicable Federal, State, or local laws, statutes, or regulations.

Implementation of Service recommendations provided in accordance with these guidelines by the wind energy industry is voluntary. Field offices have discretion in the use of these guidelines on a case-by-case basis, and may also have additional recommendations to add which are specific to their geographic area.

The Migratory Bird Treaty Act (16 U.S.C. 703-712) prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. While the Act has no provision for allowing an unauthorized take, it must be recognized that some birds may be killed at structures such as wind turbines even if all reasonable measures to avoid it are implemented. The Service's Office of Law Enforcement carries out its mission to protect migratory birds not only through investigations and enforcement, but also through fostering relationships with individuals and industries that proactively seek to eliminate their impacts on migratory birds. While it is not possible under the Act to absolve individuals, companies, or agencies from liability if they follow these recommended guidelines, the Office of Law Enforcement and Department of Justice have used enforcement and prosecutorial discretion in the past regarding individuals, companies, or agencies who have made good faith efforts to avoid the take of migratory birds.

Please ensure that all field personnel involved in review of wind energy development proposals receive copies of this memorandum. Questions regarding this issue should be directed to Dr. Benjamin N. Tuggle, Chief, Division of Federal Program Activities, at (703) 358-2161, or Brian Millsap, Chief, Division of Migratory Bird Management, at (703) 358-1714.

Attachment

INTERIM GUIDELINES TO AVOID AND MINIMIZE WILDLIFE IMPACTS FROM WIND TURBINES

Introduction

Wind-generated electrical energy is renewable, produces no emissions, and is generally considered to be an environmentally friendly technology. Development of wind energy is strongly endorsed by the Secretary of the Interior, as expressed in the Secretary's Renewable Energy on Public Lands Initiative (May 2002). However, wind energy facilities can adversely impact wildlife, especially birds (e.g., Orloff and Flannery 1992, Leddy et al. 1999, Woodward et al. 2001, Braun et al. 2002, Hunt 2002) and bats (Keeley et al. 2001, Johnson et al. 2002, Johnson et al. 2003). As more facilities with larger turbines are built, the cumulative effects of this rapidly growing industry may initiate or contribute to the decline of some wildlife populations (Manes et al. 2002, Johnson et al. 2002, Manville 2003). The potential harm to these populations from an additional source of mortality or adverse habitat impacts makes careful evaluation of proposed facilities essential. Due to local differences in wildlife concentration and movement patterns, habitats, area topography, facility design, and weather, each proposed development site is unique and requires detailed, individual evaluation.

The following guidance was prepared by the U.S. Fish and Wildlife Service (Service). Like the Service's voluntary guidance addressing the siting, construction, operation, and decommissioning of communication towers (http://migratorybirds.fws.gov/issues/towers/comtow.html) and the voluntary guidance developed in cooperation with the electric utility industry to minimize bird strikes and electrocutions (APLIC 1994, APLIC 1996), this guidance is intended to assist the wind energy industry in avoiding or minimizing impacts to wildlife and their habitats. This is accomplished through: (1) proper evaluation of potential Wind Resource Areas (WRAs), (2) proper location and design of turbines and associated structures within WRAs selected for development, and (3) pre- and post-construction research and monitoring to identify and/or assess impacts to wildlife. These guidelines are based on current science and will be updated as new information becomes available. They are voluntary, and interim in nature. They will be evaluated over a two-year period, and then modified as necessary based on their performance in the field, on comments from the public, and on the latest scientific and technical discoveries developed in coordination with industry, states, academic researchers, and other Federal agencies. After this period, the Service plans to develop a complete operations manual for evaluation, site selection, design, construction, operation, and monitoring of wind energy facilities in both terrestrial and aquatic environments.

Data on wildlife use and mortality collected at one wind energy facility are not necessarily applicable to others; each site poses its own set of possibilities for negative effects on wildlife. In addition, the wind industry is rapidly expanding into habitats and regions that have not been well studied. The Service therefore suggests a precautionary approach to site selection and development, and will employ this approach in making recommendations and assessing impacts of wind energy developments. We encourage the wind energy industry to follow these guidelines and, in cooperation with the Service, to conduct scientific research to provide additional information on the impacts of wind energy development on wildlife. We further encourage the industry to look for opportunities to promote bird and other wildlife conservation when planning wind energy facilities (e.g., voluntary habitat acquisition or conservation easements).

The Service is guided by the Fish and Wildlife Service Mitigation Policy (Federal Register 46 (15), January 1981) in evaluating modifications to or loss of habitat caused by development. This policy follows the sequence of steps recommended in the Council on Environmental Quality's Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (NEPA) in seeking to avoid, minimize, or compensate for negative impacts. Mitigation can involve (1) avoiding the impact of an activity by taking no action; (2) minimizing impacts by limiting the degree of activity; (3) rectifying an impact by repairing, rehabilitating, or restoring an affected environment; (4) reducing or eliminating an impact by conducting activities that preserve and maintain the resources; or (5) compensating for an impact by replacing or providing substitute resources or environments. Any mitigation recommended by the Service

for wind energy development would be voluntary on the part of the developer unless made a condition of a Federal license or permit. Mitigation does not apply to "take" of species under the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, or Endangered Species Act. The goal of the Service under these laws is the elimination of loss of migratory birds and endangered and threatened species due to wind energy development. The Service will actively expand partnerships with regional, national, and international organizations, States, tribes, industry, and environmental groups to meet this goal.

Projects with Federal involvement may require additional analysis under the National Environmental Policy Act (http://www.fws.gov/r9esnepa), Endangered Species Act (http://endangered.fws.gov), or National Wildlife Refuge System Administration Act (http://www.fws.gov/policyMakers/mandates/index.html#adminact). This includes projects on federally-owned lands (e.g., National Wildlife Refuges, National Forests), lands where a Federal permit is required for development (e.g., BLM-administered lands), or lands where Federal funds were used for purchase or improvement (some State Wildlife Management Areas).

These guidelines are not intended nor shall they be construed to limit or preclude the Service from exercising its authority under any law, statute, or regulation, and to take enforcement action against any individual, company, or agency, or to relieve any individual, company, or agency of its obligations to comply with any applicable Federal, State, or local laws, statutes, or regulations.

The guidelines contain a site evaluation process with checklists for pre-development evaluations of potential terrestrial wind energy development sites (Appendix 1). Use of this process allows comparison of one site with another with respect to the impacts that would occur to wildlife if the area were developed. The evaluation area for a potential development site should include the "footprint" encompassing all of the turbines and associated structures planned for that proposed facility, and the adjacent wildlife habitats which may be affected by the proximity of the structures, but excluding transmission lines extending outside the footprint. All potential development sites within a geographic area should be evaluated before a site is selected for development.

Pre-development evaluations should be conducted by a team that includes Federal and/or State agency wildlife professionals with no vested interest (e.g., monetary or personal business gain) in the sites selected. Teams may also include academic and industry wildlife professionals as available. Any site evaluations conducted by teams that do not include Federal and/or State agency wildlife professionals will not be considered valid evaluations by the Service.

The pre-development evaluation may also identify additional studies needed prior to and after development. Post-construction monitoring to identify any wildlife impacts is recommended at all developed sites. Pre- and post-development studies and monitoring may be conducted by any qualified wildlife biologist without regard to his/her affiliation or interest in the site.

Additional information relevant to these guidelines is appended as follows:

Appendix 2 – Definitions Related to Wind Energy Development and Evaluation
Appendix 3 – Wildlife Laws Relevant to Wind Power Development Projects
Appendix 4 - Research Needs on the Impacts of Wind Power Development on Wildlife
Appendix 5 – Procedures for Endangered Species Evaluations and Consultations
Appendix 6 – Guidelines for Considering Wind Turbine Siting on Easement Lands Administered as Part of the National Wildlife Refuge System in Region 6 (CO, KS, MT, NE, ND, SD, UT, WY)
Appendix 7 – Known and Suspected Impacts of Wind Turbines on Wildlife
Appendix 8 – Literature Cited

Site Evaluation

The site evaluation protocol presented in Appendix 1 was developed by a team of Federal, State, university, and wind energy industry biologists to rank potential terrestrial wind energy development sites by their potential impacts on wildlife. There are two steps to follow:

1. Identify and evaluate reference sites, preferably within the general geographic area of the proposed facility. Reference sites are high-quality wildlife areas where wind development would result in the maximum negative impact on wildlife (i.e., sites selected to have the highest possible rank using the protocol). Reference sites are used to determine the comparative risks of developing other potential sites.

2. Evaluate potential development sites to determine risk to wildlife and rank sites against each other using the highest-ranking reference site as a standard. Although high-ranking sites are generally less desirable for wind energy development, a high rank does not necessarily preclude development of a site, nor does a low rank automatically eliminate the need to conduct pre-development assessments of wildlife resources or post-development assessments of impacts.

Studies to Assess and Monitor Wildlife Impacts

While ranking potential development sites, the site evaluation team referenced above may identify pre-development studies that are needed to better assess potential negative impacts to wildlife. Ranking may also suggest the extent and duration of study required. Developers are encouraged to conduct any studies suggested by the team in coordination with Service and other agency wildlife biologists.

Post-development mortality studies should be a part of any site development plan in order to determine if or to what extent mortality occurs. As with pre-development studies, ranking may suggest the extent and duration of study needed. Studies should be designed in coordination with Federal and other agency biologists.

Site Development Recommendations

The following recommendations apply to locating turbines and associated structures within WRAs selected for development of wind energy facilities:

1. Avoid placing turbines in documented locations of any species of wildlife, fish, or plant protected under the Federal Endangered Species Act.

2. Avoid locating turbines in known local bird migration pathways or in areas where birds are highly concentrated, unless mortality risk is low (e.g., birds present rarely enter the rotor-swept area). Examples of high concentration areas for birds are wetlands, State or Federal refuges, private duck clubs, staging areas, rookeries, leks, roosts, riparian areas along streams, and landfills. Avoid known daily movement flyways (e.g., between roosting and feeding areas) and areas with a high incidence of fog, mist, low cloud ceilings, and low visibility.

3. Avoid placing turbines near known bat hibernation, breeding, and maternity/nursery colonies, in migration corridors, or in flight paths between colonies and feeding areas.

4. Configure turbine locations to avoid areas or features of the landscape known to attract raptors (hawks, falcons, eagles, owls). For example, Golden Eagles, hawks, and falcons use cliff/rim edges extensively; setbacks from these edges may reduce mortality. Other examples include not locating turbines in a dip or pass in a ridge, or in or near prairie dog colonies.

5. Configure turbine arrays to avoid potential avian mortality where feasible. For example, group turbines rather than spreading them widely, and orient rows of turbines parallel to known bird movements, thereby decreasing the potential for bird strikes. Implement appropriate storm water management practices that do not create attractions for birds, and maintain contiguous habitat for area-sensitive species (e.g., Sage Grouse).

6. Avoid fragmenting large, contiguous tracts of wildlife habitat. Where practical, place turbines on lands already altered or cultivated, and away from areas of intact and healthy native habitats. If not practical, select fragmented or degraded habitats over relatively intact areas.

7. Avoid placing turbines in habitat known to be occupied by prairie grouse or other species that exhibit extreme avoidance of vertical features and/or structural habitat fragmentation. In known prairie grouse habitat, avoid placing turbines within 5 miles of known leks (communal pair formation grounds).

8. Minimize roads, fences, and other infrastructure. All infrastructure should be capable of withstanding periodic burning of vegetation, as natural fires or controlled burns are necessary for maintaining most prairie habitats.

9. Develop a habitat restoration plan for the proposed site that avoids or minimizes negative impacts on vulnerable wildlife while maintaining or enhancing habitat values for other species. For example, avoid attracting high densities of prey animals (rodents, rabbits, etc.) used by raptors.

10. Reduce availability of carrion by practicing responsible animal husbandry (removing carcasses, fencing out cattle, etc.) to avoid attracting Golden Eagles and other raptors.

Turbine Design and Operation Recommendations

1. Use tubular supports with pointed tops rather than lattice supports to minimize bird perching and nesting opportunities. Avoid placing external ladders and platforms on tubular towers to minimize perching and nesting. Avoid use of guy wires for turbine or meteorological tower supports. All existing guy wires should be marked with recommended bird deterrent devices (Avian Power Line Interaction Committee 1994).

2. If taller turbines (top of the rotor-swept area is >199 feet above ground level) require lights for aviation safety, the minimum amount of pilot warning and obstruction avoidance lighting specified by the Federal Aviation Administration (FAA) should be used (FAA 2000). Unless otherwise requested by the FAA, only white strobe lights should be used at night, and these should be the minimum number, minimum intensity, and minimum number of flashes per minute (longest duration between flashes) allowable by the FAA. Solid red or pulsating red incandescent lights should not be used, as they appear to attract night-migrating birds at a much higher rate than white strobe lights.

3. Where the height of the rotor-swept area produces a high risk for wildlife, adjust tower height where feasible to reduce the risk of strikes.

4. Where feasible, place electric power lines underground or on the surface as insulated, shielded wire to avoid electrocution of birds. Use recommendations of the Avian Power Line Interaction Committee (1994, 1996) for any required above-ground lines, transformers, or conductors.

5. High seasonal concentrations of birds may cause problems in some areas. If, however, power generation is critical in these areas, an average of three years monitoring data (e.g., acoustic, radar, infrared, or observational) should be collected and used to determine peak use dates for specific sites. Where feasible, turbines should be shut down during periods when birds are highly concentrated at those sites.

6. When upgrading or retrofitting turbines, follow the above guidelines as closely as possible. If studies indicate high mortality at specific older turbines, retrofitting or relocating is highly recommended.

Appendix 1

PROTOCOL TO RANK POTENTIAL TERRESTRIAL WIND ENERGY DEVELOPMENT SITES BY IMPACTS ON WILDLIFE

This protocol was developed by a team of Federal, State, university, and industry biologists to rank potential wind development sites in Montana by their potential for impacts on wildlife (USFWS 2002). It has been modified to apply nationwide. The protocol allows the user to evaluate potential development sites and rank them against a reference site. Objectives are to: (1) assist developers in deciding whether to proceed with development; (2) provide a procedure to determine pre-construction study needs to verify use of potential sites by wildlife; and (3) provide recommendations for monitoring potential sites post-construction to identify, quantify, or verify actual impacts (or lack thereof).

Although this protocol focuses on impacts to wildlife, potential impacts to fish, other aquatic life, and plants should be considered as well. Surveys for rare, threatened, or endangered plants known or suspected to occur in the geographic area should be conducted at all proposed terrestrial development sites having suitable habitat.

This protocol is intended to provide a conceptual framework for initial steps in investigating a site. It is not intended to be all-inclusive relative to objectives, methods, and analysis nor to serve as the definitive reference or directive for any step in wind power related investigations. The Physical Attributes, Species Occurrence and Status, and Ecological Attractiveness groupings in this protocol should serve as a model framework; the terrain features, species, and conditions used in these groupings will be dictated by local conditions and should be developed by wildlife biologists familiar with the region in which this protocol is being used.

Potential Impact Index (PII)

The Potential Impact Index represents a “first cut” analysis of the suitability of a site proposed for development. It does so by estimating use of the site by selected wildlife species as an indicator of potential impact. Emphasis of the PII is on initial site evaluation and is intended to provide more objectivity than simple reconnaissance surveys.

There are two steps to follow in ranking sites by their potential impact on wildlife:

1. Identify and evaluate reference sites within the general geographic area of Wind Resource Areas (WRA’s) being considered for development of a facility. Reference sites are areas where wind development would result in the maximum negative impact on wildlife, resulting in a high PII score. Reference sites are used to determine the comparative risks of developing other potential sites.

2. Evaluate potential development sites to determine risk to wildlife, and rank sites against each other using the highest-ranking reference site as a standard. While high-ranking sites are generally less desirable for wind development, a high rank does not necessarily preclude development of a site, not does a low rank automatically eliminate the need to conduct pre-development assessments of wildlife use and impact potential.

The following assumptions are implicit in the PII process:

1. All WRA sites, regardless of turbine design, configuration, placement, or operation present some hazard and risk to wildlife from both an individual and population perspective.

2. Certain sites present less hazard and risk to wildlife than others.

3. No adequate and defensible information exists regarding the appropriateness of the proposed WRA site being evaluated relative to impacts to wildlife.

4. Evaluations will be conducted by qualified biologists without competitive interest in site selection, including those from State and Federal agencies who are familiar with local and regional wildlife.

The PII is designed primarily to evaluate potential impacts on aerial wildlife from collision with turbines and infrastructure. The PII is derived from the results of three checklists (forms are attached). These checklists should be developed and applied as follows:

A. The PHYSICAL ATTRIBUTE checklist considers topographic, meteorological, and site characteristics that may influence bird and bat occurrence and movements.

B. The SPECIES OCCURRENCE AND STATUS checklist includes: Birds of Conservation Concern at the Bird Conservation Region level (http://migratorybirds.fws.gov/reports/reports.html); all federally-listed Endangered, Threatened, and Candidate Species (http://endangered.fws.gov); bird species of high recreational or other value (e.g., waterfowl, prairie grouse); State Endangered, Threatened, and Species of Management Concern; and any additional species of concern listed by State Natural Heritage Programs.

C. The ECOLOGICAL ATTRACTIVENESS checklist evaluates the presence and influence of ecological magnets and other conditions that would draw birds or bats to the site or vicinity.

Each checklist has boxes to be checked for a particular attribute or species found at an evaluation site. The number of boxes in each checklist will vary from region to region due to variations in the number of physical attributes and species of concern in that region. Keep in mind that all boxes in a checklist are very unlikely to be checked at a single evaluation site, because all species and ecological physical conditions potentially occurring in the region would not exist at one site.

Each checklist should be assigned a divisor, which is developed by dividing the number of boxes in a checklist by the total number of boxes in all three checklists. This expands the spread of index values and more dramatically displays the magnitude of differences among sites. For example, if the PHYSICAL ATTRIBUTE checklist has 36 boxes and the total number of boxes in all three checklists is 144, divide 36 by 144 = 0.25, the divisor.

You can change the number of boxes in any of the checklists to fit your geographic area, habitat type, or other selected region (e.g., a state or portion of a state). Remember to recalculate the divisor if you change the number of boxes.

Boxes in a checklist are checked if the condition or species is known or strongly suspected to occur. Criteria for checklist conditions marked with an asterisk (*) are explained on the following page. Conditions that are self-explanatory are not included. Conditions are not weighted. Boxes are checked in the SPECIES OCCURRENCE AND STATUS checklist if presence of the species is unconfirmed but strongly suspected (i.e., WRA is within the range and habitat of the species). This permits more liberal assignment of potential impact, reduces the probability of missing impacts on specific species due to lack of empirical data, and focuses future study and monitoring effort. Totals for each checklist are simple column sums. The PII is calculated from the checklist totals. A completed example from Montana is provided at the end of this Appendix.

Determining Checklist Scores

Checklist scores are determined as follows:

1. Place a check in each box for which an attribute, species, or condition is present or strongly suspected.

2. After completing the three checklists for each site, add the total number of checks in a checklist for an ending sum (each box checked equals one).

Determining PII Score

The Potential Impact Index score is determined as follows:

1. Place the sums from each of the three checklists in the POTENTIAL IMPACT INDEX table sum boxes (Σ column) in the appropriate category.

2. Divide each checklist sum by the previously calculated divisor to adjust the sum for disproportionate numbers of conditions in each checklist, and place this adjusted sum in the Σ/p boxes for each checklist.

3. Add the adjusted checklist sums (Σ/p column) to produce the PII score.

Include any questions, statements, comments, or concerns regarding any checklist cell or category on the SITE SPECIFIC COMMENTS sheet. These comments are critical to determining pre-construction study needs. They will also help identify and refine questions and objectives to be addressed by follow-up study and monitoring. The nature of suspected Significant Ecological Events should be noted on the SITE SPECIFIC COMMENTS sheet.

Ranking PII Scores

PII of each site evaluated is assigned a ranking based on its proportional relationship to the reference site that has the maximum PII score, as shown in Figure 2 in the Montana example. Ranking categories (High, Low, etc.) in the example are arbitrarily set at intervals of 20 percent of maximum.

Rankings are intended as a guide to developers. They are designed to serve as indicators of relative risk to wildlife and thus provide an estimator of the level of impact that may be expected should a site be developed. A high rank does not preclude development, nor does a low rank automatically eliminate the need to conduct pre-development assessments of impacts on wildlife. More intensive pre-construction studies may be needed for both scenarios if development of the site is pursued. Rankings may also suggest the extent of additional study needed.

In the case of federally listed threatened, endangered, or candidate species of wildlife, fish, or plants, consultation with the Fish and Wildlife Service under the Endangered Species Act is required, and may preclude development of a site regardless of its PII score. See Appendix 5 for procedures for obtaining lists of these species that may be present, and for consulting with the Fish and Wildlife Service if species or their habitats are found.

Determining Pre-construction Study Needs

The goals of pre-construction studies are to estimate impacts of proposed wind power development on wildlife by addressing areas of concern identified during the PII process. Objectives, intensity, duration, and methods of pre-construction studies are likely to be site specific, but may be independent of ranking. Regardless of ranking, studies should be designed to address (1) verification of use of WRAs by all species recorded in the “SPECIES OCCURRENCE AND STATUS” checklist, (2) verification of natural conditions (e.g., under “Significant Ecological Events”, the magnitude, timing, and location of suspected bird/bat migration), or (3) questions noted in the SITE SPECIFIC COMMENTS sheet for that site. The SITE SPECIFIC COMMENTS sheet may also indicate conditions that need not be investigated. As a result, a site with a low rank may require radar surveillance (e.g., important songbird migration site) while a site with a high rank may require only a single season visual survey (e.g., site potentially contains autumn Whooping Crane habitat). The process should involve a feedback mechanism within an adaptive management strategy (Figure 1). Timely review of study results will determine if data are

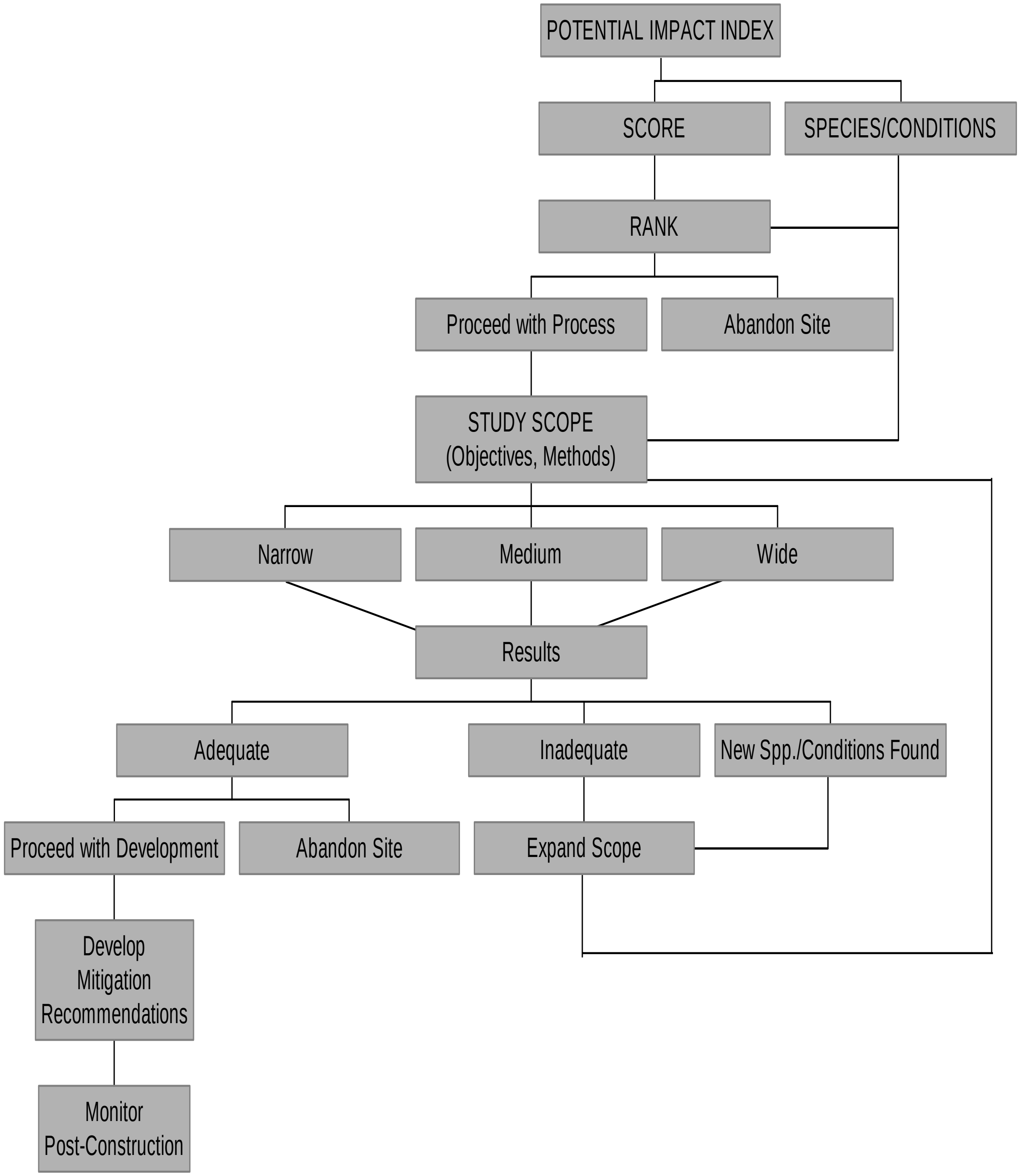


Figure 1. A suggested decision tree for assessing potential development sites. Begin by developing a PII score.

adequate, if conclusions are defensible (Anderson et al. 1999), and if additional investigational effort is required (e.g., if Black-footed Ferrets are found on Mountain Plover searches). Projects with Federal involvement may require additional analysis under the National Environmental Policy Act (http://www.fws.gov/r9esnepa), Endangered Species Act (http://endangered.fws.gov), or National Wildlife Refuge System Administration Act (http://www.fws.gov/policyMakers/mandates/index.html#adminact). Also, the mere existence of a pre-construction study, whether in progress or completed, does not imply Federal sanction for development of a site.

Post-construction Studies

The Service recommends that all sites be monitored for impacts on wildlife after construction is completed. Some sites may be so obviously benign that little more than simple reconnaissance study may be needed and any impact will be revealed during post-construction monitoring. Otherwise, pre-construction studies should be designed to explicitly consider post-construction monitoring that permits statistically valid evaluation of actual impacts. Accordingly, studies should be conducted as much as possible within a Before-After-Control-Impact (BACI) study design (Green 1979). Such design requires investigation of at least two sites (Impact [proposed site] and Control) simultaneously, both pre-construction (Before) and post-construction (After). Because true "Control" sites are seldom available, other sites may be substituted, including reference sites used in developing the PII ranking. In the case of radar surveillance studies, sites within the proposed WRA boundaries may be acceptable (e.g., Harmata et al. 1998). Structuring pre-construction studies within a hypotheses-testing framework will help identify appropriate metrics, focus effort, and permit comparisons with post-construction conditions or other WRAs.

Where feasible, post-construction studies should also be utilized to test measures that may eliminate or reduce impacts on wildlife. See Appendix 4, Research Needs on the Impacts of Wind Power Development on Wildlife.

Metrics and Methods

Metrics and methods are specific tools used to assess wildlife populations and their status (e.g., point counts, line transects, nest success studies, radar surveys, mortality rates, and risk). They can provide important information about birds, bats, and other wildlife at proposed development sites. Metrics and methods may be selected to collect seasonal, group, guild, or habitat specific information, based on data and comments in the SPECIES OCCURRENCE AND STATUS checklist and SITE SPECIFIC COMMENTS sheet. For example, a proposed WRA may be in a narrow north-south oriented valley of relatively monotypic habitat. These conditions suggest a heavy seasonal avian migration corridor but little avian breeding habitat. Accordingly, study emphasis should be on defining use and mortality of migratory birds during autumn or spring or both, with little effort directed at defining use and mortality of breeding birds. Conversely, a potential WRA on a flat plain in diverse habitat would indicate the exact opposite in study emphasis.

While metrics represent specific measurements, concepts, and relationships, methods refer to observational or manipulative study techniques that may be used to verify the location of birds and other wildlife, estimate their numbers, and document their use and behavior (Anderson et al. 1999). Table 1 depicts some commonly used metrics and methods for wildlife studies.

Table 1. Examples of metrics and methods associated with evaluating use and mortality of wildlife at proposed Wind Resource Areas in Montana.

Data Need	Metric	Methods
Use Profile	Individuals/Count	Point Counts (birds) Winter Raptor Surveys Lek Counts (grouse) Migration Counts Ungulate Surveys Spotlight Surveys

	Species/Count	Species/guild/group List Point Counts (birds) Raptor Nesting Surveys Raptor Migration Counts Winter Raptor Surveys Acoustic Surveillance (bats) Pellet Counts Bait Stations Track Boards
	Use per unit of time (e.g., hour, season)	Radar Migration Counts Raptors/watch Area Searches
	Individuals/capture effort	Various techniques for capture
	Productivity	Nests/area Raptor Nesting Surveys Nest Success Ungulate Surveys
	Events/height category (Altitude Profile)	Radar
	Events/distance category (Spatial Profile)	Radar
Mortality	Dead/injured individuals/unit	Transects Spot Searches Carcass Removal Study Observer Detection Efficiency Study

Studies should also strive to generate information to mitigate impacts by properly locating, configuring, or operating turbines (Johnson et al. 2000). Every effort should be made to choose metrics and methods that allow comparisons of pre-construction studies with post-construction studies, other WRAs, and other regions.

Interpreting Metrics

It may be difficult to establish empirically exactly what constitutes high use (i.e., potentially high impact). When looking at the distribution and movements, and local, regional, or range-wide population estimates for particular species, the relative proportions of species, groups, or guilds of wildlife using proposed WRAs may indicate degrees of risk. If baseline population data are unknown, consult with a qualified biologist who can recommend a specific metric.

It is likely that little or no evidence of mortality will be found during pre-construction study. If, however, post-construction mortality is found, and statistical evaluation is not possible, that mortality should be assessed in regard to the species status (e.g., ESA-listed species or Birds of Conservation Concern) or the effect of the loss of individuals of that species on a local, regional, or continental population.

Determining Post-construction Monitoring Needs

Post-construction monitoring is important to the Service, industry, and public because of the limited information available on impacts of wind turbines and WRAs on wildlife. Therefore, post-construction monitoring should be designed to detect major impacts. The intended time frame for post-construction monitoring is not expected to exceed three years, however. Major impacts may be considered as statistically significant decreases in use by species of concern, or limited to statistically significant increases in mortality rates of any wildlife. Monitoring effort may be intensive or cursory, depending on results of pre-construction use and mortality studies. Simple, infrequent mortality surveys on impact and

control plots may be all that is needed at WRAs where recorded pre-construction use by wildlife is low. Documented high use of a proposed WRA may require monitoring methods identical to those employed in pre-construction studies. Anderson et al. (1999) provide specific, detailed direction in post-construction study design and monitoring. Manville (2002) developed a monitoring protocol for use by the U.S. Forest Service at three National Forests in Arizona to monitor the impact of cellular telecommunications towers on migratory birds that could be modified for use at land-based wind turbines.

POTENTIAL IMPACT INDEX CHECKLIST FORMS AND INSTRUCTIONS

PHYSICAL ATTRIBUTE CHECKLIST

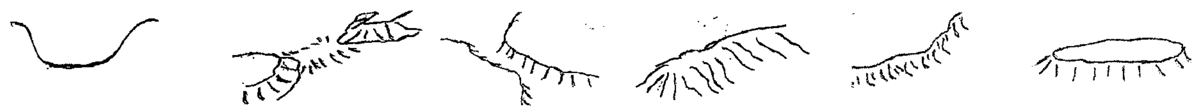
Physical Attribute				Site			
Topography	Mountain Aspect, if mountainous*	Side	W				
			E				
			N				
			S				
		Top					
		Foothill	W				
			E				
			N				
			S				
Wind* Direction	S						
	N						
	E						
	W						
	Updrafts*						
Migratory* Corridor Potential	Latitudinal (N ↔ S)						
	Longitudinal (E ↔ W)						
	Wide Approaches (>30 km)*						
	Funnel Effect	Horizontal					
		Vertical					
Site Size (acres) & Configuration*	<640						
	>640 <1000						
	>1000 <1500						
	Turbine Rows not Parallel to						
Infrastructure To Build	Transmission						
	Roads						
	Buildings*						
			Maintenance				
			Daily Activity				
	Substation						
Increased Activity*							
			Totals				

∗ Criteria on following page

PHYSICAL ATTRIBUTE CRITERIA - categories, max Σ = , (p =).

Topography - Terrain characteristic within the ecological influence of the proposed wind development site, generally, but not restricted to ± 5 mi. Some examples are:

Valley Pass Gap Ridgetop Bluff Butte



Mountain Aspect - Aspect of topography for site of proposed development. Multiple categories may be checked.

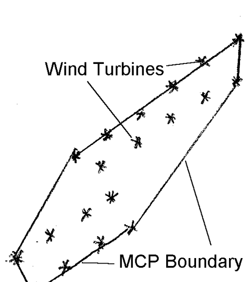
Wind Direction - Compass direction *from* which prevailing winds approach. Multiple categories may be checked.

Updrafts - Do updrafts/upslope winds prevail?

Migratory Corridor Potential - Subjective estimate of area to be a potential avian/bat migratory corridor based strictly on topographical characteristics. Multiple categories may be checked.

- Wide (>20 mi) - Terrain characteristics of approaches to site from each migratory direction, i.e., a large plain, river corridor, long valley. The larger the area that migrant birds/bats are drawn from, the more may be at risk
- Funnel Effect - Is the site in or near an area where migrant birds/bats may be funneled (concentrated) into a smaller area, either altitudinally, laterally, or both?

Site Size & Configuration – Size is estimated as if a minimum convex polygon (MCP) were drawn around peripheral turbines.



Successive boxes are checked to convey relationship of larger size = increased impact to birds/bats, *e.g.*, a 700 acre site will have 2 categories checked while a 1,200 acre site will have all 3 categories checked.

Configuration of turbine rows is usually perpendicular to prevailing wind direction. Rows aligned perpendicular or oblique to route of migration intuitively presents more risk to birds than rows aligned parallel to movement.

Buildings – Building are categorized by relative size and visitation frequency, *i.e.*, structures that are visited daily are usually larger and present more impact than those that are not. If a “Daily Activity” building is required, all Building categories are checked. If a maintenance structure is required, Substation is also checked.

Increased Activity - Will any type of human activity increase? Sites in urban-suburban or otherwise developed areas (oil, gas, mines) will have less impact on wildlife than those in remote or undeveloped areas.

Avian Species of Concern Checklist
(Complete prior to SPECIES OCCURRENCE & STATUS Checklist)

	Site											
Birds (n =)												
Occurrence	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Subtotals												
Total												

Avian Species of Concern Checklist (species, max Σ =   )

Column totals of this list are added to appropriate cells in the SPECIES OCCURRENCE & STATUS checklist. Consult Birds of Conservation Concern (http://migratorybirds.fws.gov/reports/reports.html) and Threatened/Endangered Species list (http://endangered.fws.gov), and list other species of high value or management concern such as migratory waterfowl and prairie grouse. Appropriate avian field guides and species accounts should be consulted for confirmation of species distribution and habitat associations. State Natural Heritage Programs may also provide species accounts that include additional information useful in completing checklists.

In addition to species lists (rows), season of occurrence is also indicated (columns). "B" indicates breeding or summer occurrence and "M/W" indicates presence during migration or as wintering species. If occurrence within or in the vicinity of a proposed site is confirmed or suspected, an "X" is entered.

Bat Species Of Concern Checklist
(Complete prior to SPECIES OCCURRENCE & STATUS Checklist)

	Site											
Bats (n =)												
Occurrence	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Subtotals												
Total												

Bat Species Of Concern Checklist (species, max Σ =).

Column totals of this list are added to appropriate cells in the SPECIES OCCURRENCE & STATUS checklist. Appropriate bat field guides and references (Barbour and Davis 1969) should be consulted for confirmation of species distribution and habitat associations. State Natural Heritage Programs may also provide species accounts that include additional information useful in completing checklists.

In addition to species lists (rows), season of occurrence is also indicated (columns). “B” indicates breeding or summer occurrence and “M/W” indicates presence during migration or as wintering species. If occurrence within or in the vicinity of a proposed site is confirmed or suspected, an “X” is entered.

SPECIES OCCURRENCE & STATUS CHECKLIST

Species		Site											
	Occurrence	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Threatened & Endangered (includes wildlife, fish, and plants)													
Candidate*													
Special Concern*	Birds (max Σ=)												
	Bats (max Σ=)												
Subtotals													
Total													

∗ Criteria on following page

SPECIES OCCURRENCE & STATUS Checklist (categories, max Σ = , (p =).

Checklist totals for each column in "Avian Species of Concern List" and "Bat Species of Concern List" are inserted in this checklist.

Threatened & Endangered Species - Species on the Federal List of Endangered and Threatened Species (http://endangered.fws.gov).

Candidate Species - Species being investigated for inclusion in the Federal List of Endangered and Threatened Species (http://endangered.fws.gov).

Species of Special Concern - Species listed in Birds of Conservation Concern; by Natural Heritage Programs that are known or suspected to be rare, endemic, disjunct, threatened or endangered; and species of high value such as migratory or other game birds.

Golden Eagles may be included in this checklist because of special protective status afforded under the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d). Other species (e.g., Sage Grouse) may be included because of recent concern over population declines range wide. Bats (other than bat Species of Special Concern) should be included due to generally unknown impacts of wind farms on individuals and populations.

ECOLOGICAL ATTRACTIVENESS CHECKLIST

Ecological Attractor			Site			
Migration Route*	Local					
	Continental*	N				
		S				
		E				
		W				
Ecological Magnets*	Lotic System					
	Lentic System					
	Wetlands					
	Native Grassland					
	Forest					
	Food Concentrated					
	Energetic Foraging					
	Vegetation/ Habitat	Unique				
		Diverse				
Significant Ecological Event*						
Site of Special Conservation Status*						
Total						

* Criteria on following page

ECOLOGICAL ATTRACTIVENESS CRITERIA - categories, max Σ = , (p =).

Migration Route - Indicates predominate direction of movement of seasonal migrations. Multiple categories may be checked.

Local - Some avian populations move only altitudinally & direction may be East-West (Sage Grouse, owls, Bald Eagles).

Continental - Some migratory corridors experience mass movements in only one season/direction annually (e.g., Bridger Mountains autumn eagle migration).

Ecological Magnets - Special, unique, unusual, or super ordinary habitats or conditions within the vicinity of the site that may attract wildlife. Lotic systems include small perennial or seasonal creeks to major rivers. Lentic systems include stock ponds to lakes to marine environments. Multiple categories may be checked.

Vegetation/Habitat - Unique or exceptionally diverse vegetation or habitat in the vicinity may indicate exceptional diversity and abundance of avian species or bats.

Significant Ecological Event - Special, unique, unusual, or super ordinary events that occur or are suspected to occur in the vicinity of the site, e.g., up to one third of the Continental population of Trumpeter Swans visit Ennis Lake, < 2.5 miles from a proposed Wind Resource Area; the Continental migration of shorebirds passes over (many stop) at Benton Lake National Wildlife Refuge) and up to 2,000 Golden Eagles pass over the Bridger Mountains in autumn. If unknown but suspected a "?" is entered. Specifics regarding the cell are then addressed in the appropriate box of the SITE SPECIFIC COMMENTS sheet to focus follow-up investigation and assist in definition of study objectives.

Site of Special Conservation Status - Any existing or proposed covenants, conservation easements, or other land development limitations intended to conserve, protect, or enhance wildlife or habitat. This criterion is weighted (2 entered if true) because of previous financial or other investment in ecological values. Specifics regarding the easement are then addressed in the appropriate box of the SITE SPECIFIC COMMENTS sheet to focus follow-up attention.

POTENTIAL IMPACT INDEX

	Site							
Checklist (p)[1]	Σ	Σ/p	Σ	Σ/p	Σ	Σ/p	Σ	Σ/p
Physical ( )								
Species Occurrence & Status ( )								
Ecological ( )								
Totals								

[1]Proportion of total checklist categories.

Determining PII Score

A. Place the sums from each of the three checklists in the POTENTIAL IMPACT INDEX table sum boxes (Σ column) in the appropriate category.

B. Divide each checklist sum by the previously calculated divisor to adjust the sum for disproportionate numbers of conditions in each checklist, and place this adjusted sum in the Σ/p boxes for each checklist.

C. Add the Σ/p boxes for the three checklists to obtain a total score.

SITE SPECIFIC COMMENTS

Checklist	**Site**			
Physical				
Species Occurrence				
Ecological				

EXAMPLE SITE ASSESSMENT AND
CALCULATION OF POTENTIAL IMPACT INDEX (PII)
FROM MONTANA

POTENTIAL IMPACT INDEX CHECKLISTS

Calculating Divisors

A. Each checklist should be assigned a divisor, which is developed by dividing the number of boxes in a checklist by the total number of boxes in all three checklists. In this example, the total number of boxes in all three checklists is 143.

B. Physical Attribute checklist: 36 boxes ÷ 143 = 0.25; Species Occurrence and Status checklist: 91 boxes ÷ 143 = 0.63; Ecological Attractiveness checklist: 16 boxes ÷ 143 = 0.11.

Determining Checklist Scores

A. Place a check in each box for which an attribute, species, or condition is present or strongly suspected.

B. After completing the three checklists for each site, add the total number of checks in a checklist for an ending sum (each box checked equals 1).

PHYSICAL ATTRIBUTE CHECKLIST

Physical Attribute				Site: Snowy Mtn.Range	Site	Site	Site
Topography	Mountain Aspect	Side	W	X			
Topography	Mountain Aspect	Side	E				
Topography	Mountain Aspect	Side	N				
Topography	Mountain Aspect	Side	S				
Topography	Mountain Aspect	Top					
Topography	Mountain Aspect	Foothill	W	X			
Topography	Mountain Aspect	Foothill	E				
Topography	Mountain Aspect	Foothill	N				
Topography	Mountain Aspect	Foothill	S				
Topography	Valley			X			
Topography	Pass						
Topography	Gap						
Topography	Ridge			X			
Topography	Bluff						
Topography	Butte						
Wind Direction	S						
Wind Direction	N			X			
Wind Direction	E						
Wind Direction	W						
Wind Direction	Updrafts			X			
Migratory Corridor Potential	Latitudinal (N ↔ S)						
Migratory Corridor Potential	Longitudinal (E ↔ W)			X			
Migratory Corridor Potential	Wide Approaches (>30 km)						
Migratory Corridor Potential	Funnel Effect	Horizontal		X			
Migratory Corridor Potential	Funnel Effect	Vertical					
Site Size (acres) & Configuration	<640			X			
Site Size (acres) & Configuration	>640 <1000			X			
Site Size (acres) & Configuration	>1000 <1500			X			
Site Size (acres) & Configuration	Turbine Rows not Parallel to						
Infrastructure To Build	Transmission			X			
Infrastructure To Build	Roads			X			
Infrastructure To Build	Buildings			X			
Infrastructure To Build			Maintenance	X			
Infrastructure To Build			Daily Activity	X			
Infrastructure To Build	Substation			X			
Increased Activity				X			
			Totals	18			

Avian Species of Concern Checklist
(Complete prior to SPECIES OCCURRENCE & STATUS Checklist)

Site

Birds (n = 12)	Snowy Mtn. R.											
Occurrence	B	M/W	∑	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Nelson's Sharptailed Sparrow	X	X	2									
LeConte's Sparrow	X	X	2									
Baird's Sparrow	X	X	2									
Dickcissel	X		1									
Cassion's Kingbird	X		1									
Blackbacked Woodpecker	X		1									
Yellow-billed Cuckoo	X		1									
Peregrine Falcon	X		1									
Northern Goshawk		X	1									
Ferruginous Hawk		X	1									
Clark's Grebe	X		1									
Common Loon	X		1									
Subtotals	10	5	15									
Total			15									

Bat Species Of Concern Checklist
(Complete prior to SPECIES OCCURRENCE & STATUS Checklist)

	Site											
Bats (n = 2)	Snowy Mtn. Range											
Occurrence	B	M/W	∑	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Fringed Myotis	X		1									
Spotted Bat	X		1									
Subtotals	2		2									
Total			2									

SPECIES OCCURRENCE & STATUS CHECKLIST

		Site											
Species		Snow Mtn. R.											
	Occurrence	B	M/W	∑	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Threatened & Endangered	Bald Eagle		X	1									
Candidate	Columbian Sharp-tailed Grouse	X	X	2									
Special Concern	Birds (max ∑=)			15									
	Bats (max ∑=)			2									
Subtotals				20									
Total				20									

ECOLOGICAL ATTRACTIVENESS CHECKLIST

Ecological Attractor			Site: Snowy Mtn. Range			
Migration Route		Local				
	Continental	N	X			
		S	X			
		E				
		W				
Ecological Magnets		Lotic System				
		Lentic System				
		Wetlands	X			
		Native Grassland	X			
		Forest	X			
		Food Concentrated				
		Energetic Foraging	X			
	Vegetation/ Habitat	Unique				
		Diverse	X			
Significant Ecological Event						
Site of Special Conservation Status						
		Total	7			

POTENTIAL IMPACT INDEX

	Site							
Checklist (p)[1]	Σ	Σ/p	Σ	Σ/p	Σ	Σ/p	Σ	Σ/p
Physical (0.25) 15÷.25=60	15	60						
Species Occurrence & Status (0.63) 20÷.63=32	20	32						
Ecological (0.11) 7÷.11=64	7	64						
Totals	42	**156**						

[1]Proportion of total checklist categories.

Score is 156, compared to the highest reference site score of 244 (Figure 2).

Determining PII Score

A. Place the sums from each of the three checklists in the POTENTIAL IMPACT INDEX table sum boxes (Σ column) in the appropriate category.

B. Divide each checklist sum by the previously calculated divisor to adjust the sum for disproportionate numbers of conditions in each checklist, and place this adjusted sum in the Σ/p boxes for each checklist.

C. Add the Σ/p boxes for the three checklists to obtain a total score.

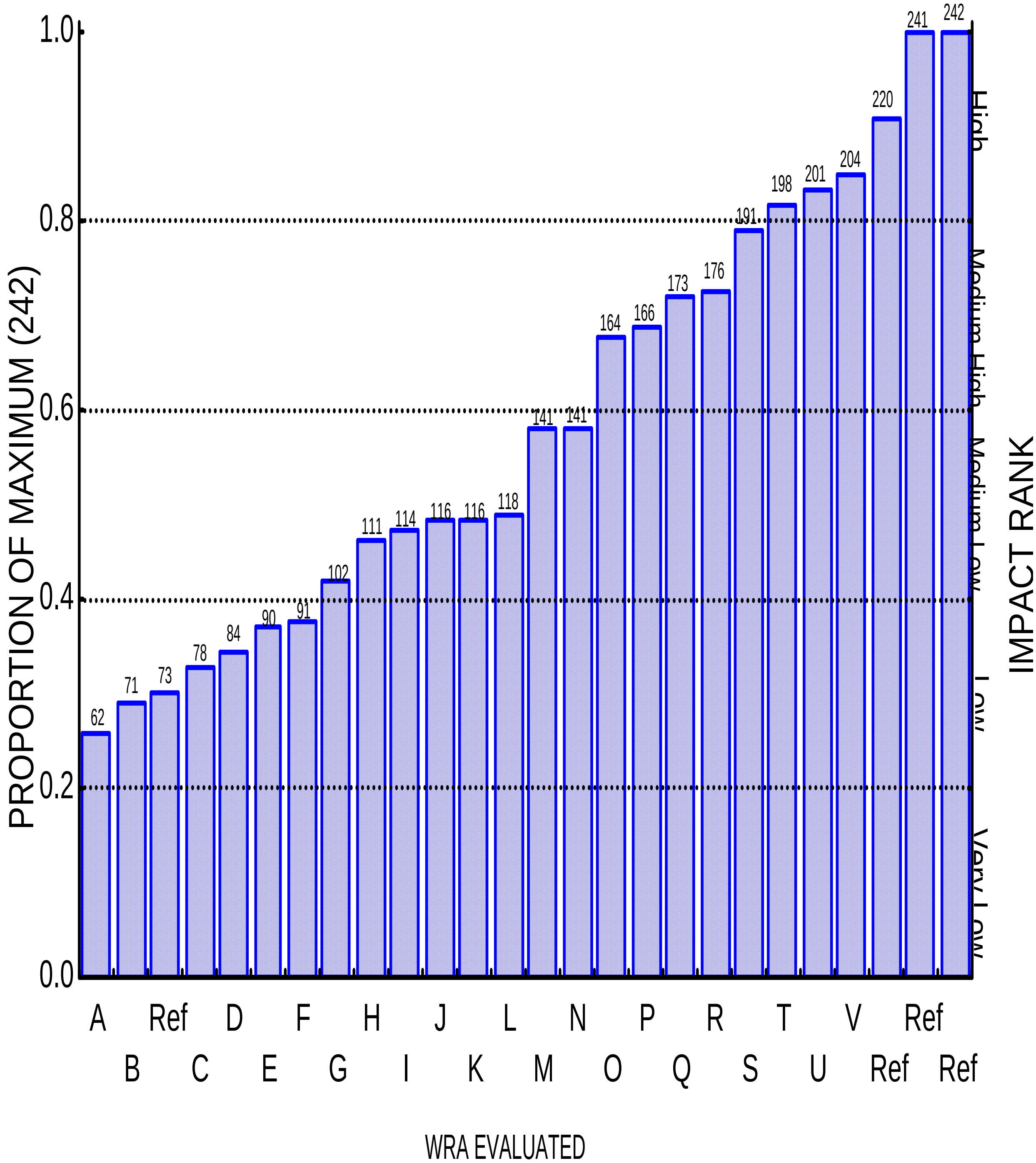


Figure 2. Impact ranks of proposed Wind Resource Areas in Montana. The number above each bar is the PII score. Rank is a function of the proportional relationship of proposed development sites to the maximum score of 4 Reference Sites evaluated.

Appendix 2

DEFINITIONS RELATED TO WIND ENERGY DEVELOPMENT AND EVALUATION

AGL: height above ground level in feet.

Breco Bird Scaring Buoy: a device developed to disperse seabirds at oil spills, which emits some 30 different sounds (including alert calls) up to 130 dB, generally effective in scaring birds at distances up to 200 yards, but may deter birds to 0.5 mile radius. The floating device can be used daytime or night, in fog, wind or storms.

Deterrent Devices: specific equipment, devices, or techniques which are intended to be seen or heard to alert and deter birds from contacting turbine towers, rotors, guy wires, or related equipment. These include diverters installed on turbine or meteorological tower guy wires, dark (e.g., black) paint on single turbine blades or portions of a blade, or noise-making devices that alert (e.g., infrasound) or frighten (e.g., Breco Buoys) birds.

Fish and Wildlife: any member of the animal kingdom, including any bird (including any migratory, non-migratory, or endangered bird for which protection is afforded), mammal, fish, amphibian, reptile, mollusk, crustacean, arthropod, or other invertebrate. Unless otherwise indicated, the Fish and Wildlife Service is particularly concerned about the impacts of wind turbines on birds and bats.

Flyway: a concentrated, predictable flight path of migratory bird species (e.g., particularly water birds such as ducks, geese, large waders, and shorebirds, but also raptors, and sometimes songbirds) from their breeding ground to wintering area. Except along coast lines, the flyway concept may not generally apply to songbirds because they tend to migrate in broad fronts rather than down specific flyways. The term "corridors" has sometimes been used. These frontal movements of songbirds can change within and between seasons and years – as can, for example, movements of waterfowl – making specific designations more difficult. The concept applies both biologically and administratively. For administrative purposes, for example, there are four waterfowl flyways (Atlantic, Pacific, Central, and Pacific and three shorebird flyways (East, Central, and Pacific). "Daily flyways" may also exist between roosting, breeding, and feeding areas.

Lek: A traditional site used year after year by males of certain species of birds (in North America, Greater and Lesser Prairie-chickens, Sage and Sharp-tailed grouse, and Buff-breasted Sandpiper), within which the males display communally to compete for female mates. Dominant males secure the majority of all the matings. Pair bonds are not formed; females leave to nest and raise the young, and males do not take part in parental care.

Passerines: a scientific term for the order of songbirds, many of which winter in tropical areas.

Precautionary Approach: a conservative, scientific approach to conserving and managing habitats and species. Absent definitive data, the approach suggests taking the best steps available to initiate appropriate conservation actions. Those actions should then be refined through the use of principles of adaptive management and sound science. The absence of complete or definitive scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species, or non-target species and their environments. Specifically, developers should apply a precautionary approach widely to conservation and management of birds, bats, other fauna, flora, and affected habitats. This will protect the resources and preserve Wind Resource Areas by taking account of the best scientific evidence available.

Reference Site: an area of high wildlife value which is used to evaluate the suitability of other areas for wind energy development. Reference sites are selected by biologists familiar with the wildlife in the geographic area and habitat types where wind energy development is contemplated, and evaluated using the Ranking Protocol in Appendix 1. The reference site having the highest score, i.e., the area where wind energy development would have the greatest negative impact on wildlife, is used as the standard against which potential wind energy development sites are ranked.

Riparian Area: The vegetation, habitats, or ecosystems that are associated with streams, rivers, or lakes, or are dependent upon the existence of perennial, intermittent, or ephemeral surface or subsurface water drainage. Relative to other habitats, riparian habitats have a disproportionately high wildlife value in the drier western states due to the

presence of surface water and/or lush vegetation that is typically surrounded by harsher, arid or semi-arid environments.

Rookery: the breeding place of a colony of gregarious birds (e.g., herons) or mammals (e.g., bats).

Rotor-swept Area: generally the vertical airspace within which the turbine blades (usually 3) rotate on a pivot point or drive train rotor. The Area will vary in location depending on the direction of the prevailing wind. While "slower" turbines may operate at speeds less than 30 revolutions per minute (RPMs), turbine speeds at the blade tips can still exceed 220 miles per hour in stiff winds. Recent studies indicate that birds appear unable to recognize blade presence at rotor tips during high blade speed, referred to as the "smear effect."

Staging Area: a traditional site where migratory birds of one or more species congregate in spring and fall for varying periods of time to forage and build up fat reserves prior to launching migratory flights. The term may be used on both the breeding and wintering grounds, as well as at intermediate stopover sites used at any point along the migration route.

Turbine Position within a Row/String: the specific position of a turbine within a string or row of turbines. It may be designated as an end-row, mid-row, or lone row turbine (one not located within a row).

Wind Resource Area: the geographic area or footprint within which wind turbines are located and operated, such as the Altamont Pass, California, WRA, or where location and operation of turbines are anticipated. The term may be used to describe an existing facility, or a general area in which development of a facility is proposed. Existing facilities are known variously as "wind farms," "wind parks," or "energy parks." WRAs are selected based primarily on the reliability and availability of sufficient wind. These areas are designated by the *United States Wind Resource Map*, published by the National Renewable Energy Laboratory, Department of Energy (http://rredc.nrel.gov). The *Map* delineates wind power classifications from "marginal" to "superb" based on a Weibull wind speed index.

Appendix 3

WILDLIFE LAWS RELEVANT TO WIND POWER DEVELOPMENT PROJECTS

The Migratory Bird Treaty Act (16 U.S.C. 703-712; MBTA), which is administered by the Fish and Wildlife Service (FWS), is the cornerstone of migratory bird conservation and protection in the United States. The MBTA implements four treaties that provide for international protection of migratory birds. It is a strict liability statute wherein proof of intent is not an element of a taking violation. Wording is clear in that most actions that result in a "taking" or possession (permanent or temporary) of a protected species can be a violation. Specifically, the MBTA states:

"Unless and except as permitted by regulations … it shall be unlawful at any time, by any means, or in any manner to pursue, hunt, take, capture, kill … possess, offer for sale, sell … purchase … ship, export, import … transport or cause to be transported … any migratory bird, any part, nest, or eggs of any such bird … (The Act) prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior." The word "take" is defined as "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect."

A 1972 amendment to the MBTA resulted in inclusion of Bald Eagles and other birds of prey in the definition of a migratory bird. The MBTA provides criminal penalties for persons who, by any means or in any manner, pursue, hunt, take, capture, kill, attempt to take, capture, or kill, possess, offer for sale, sell, offer to barter, barter, offer to purchase, purchase, deliver for shipment, ship, export, import, cause to be shipped, exported, or imported, deliver for transportation, transport or cause to be transported, carry or cause to be carried, or receive for shipment, transportation, carriage, or export, any migratory bird (including Bald Eagles) as well as possessing Bald Eagles, their parts, nests, or eggs without a permit. A violation of the MBTA by an individual can result in a fine of up to $15,000, and/or imprisonment for up to 6 months, for a misdemeanor, and up to $250,000 and/or imprisonment for up to 2 years for a felony. Fines are doubled for organizations. Penalties increase greatly for offenses involving commercialization and/or the sale of migratory birds and/or their parts. Under authority of the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d; BGEPA), Bald and Golden Eagles are afforded additional legal protection. Penalties for violations of the BGEPA are up to $250,000 and/or 2 years imprisonment for a felony, with fines doubled for an organization.

While these Acts have no provision for allowing unauthorized take, the FWS realizes that some birds may be killed even if all reasonable measures to avoid the take are implemented. The FWS Office of Law Enforcement carries out its mission to protect migratory birds not only through investigations and enforcement, but also through fostering relationships with individuals, companies, and industries who seek to eliminate their impacts on migratory birds. Unless the activity is authorized, it is not possible to absolve individuals, companies, or agencies from liability even if they implement avian mortality avoidance or similar conservation measures. However, the Office of Law Enforcement focuses on those individuals, companies, or agencies that take migratory birds with disregard for their actions and the law, especially when conservation measures have been developed but are not properly implemented.

The Endangered Species Act (16 U.S.C. 1531-1544; ESA) was passed by Congress in 1973 in recognition that many of our Nation's native plants and animals were in danger of becoming extinct. The purposes of the Act are to protect these endangered and threatened species and to provide a means to conserve their ecosystems. To this end, Federal agencies are directed to utilize their authorities to conserve listed species, as well as "Candidate" species which may be listed in the near future, and make sure that their actions do not jeopardize the continued existence of these species. The law is administered by the Interior Department's FWS and the Commerce Department's National Marine Fisheries Service (NMFS). The FWS has primary responsibility for terrestrial and freshwater organisms, while the NMFS has responsibility for marine species such as whales and salmon. These two agencies work with other agencies to plan or modify Federal projects so that they will have minimal impact on listed species and their habitats. Protection of species is also achieved through partnerships with the States, with Federal financial assistance and a system of incentives available to encourage State participation. The FWS also works with private landowners, providing financial and technical assistance for management actions on their lands to benefit both listed and non-listed species.

Section 9 of the ESA makes it unlawful for a person to "take" a listed species. Take means ". . . to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." The Secretary

of the Interior, through regulations, defined the term “harm” as “an act which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.” However, permits for “incidental take” can be obtained from the FWS for take which would occur as a result of an otherwise legal activity, such as construction of wind turbines, and which would not jeopardize the species.

Section 10 of the ESA allows for the development of “Habitat Conservation Plans” for endangered species on private lands. This provision is designed to assist private landowners in incorporating conservation measures for listed species with their land and/or water development plans. Private landowners who develop and implement an approved habitat conservation plan can receive an incidental take permit that allows their development to go forward.

The National Environmental Policy Act of 1969 (42 U.S.C. 4371 et seq.; NEPA) requires that Federal agencies prepare an environmental impact statement (EIS) for Federal actions significantly affecting the quality of the human environment. “Federal Actions” are those actions in which a Federal agency is conducting the activity, providing funding for the activity, or licensing or permitting the activity. An EIS must describe the proposed action, present detailed analyses of the impacts of the proposed action and alternatives to that action, and include public involvement in the decision making process on how to proceed to accomplish the purpose of the action. The purpose of NEPA is to allow better environmental decisions to be made. The Council on Environmental Quality, established by NEPA, has promulgated regulations in 40 CFR 1500-1508 that include provisions for 1) preparing EISs and Environmental Assessments, 2) considering categorical exclusions from NEPA documentation requirements for certain agency actions, and 3) developing cooperating agency agreements between Federal agencies.

Other Federal agencies may be required by NEPA to review and comment on proposed activities as a cooperating agency with the action agency under Section 1501.6, or because of a duty to comment on federally-licensed activities for which the agency has jurisdiction by law (Section 1503.4). For the FWS, this would be the MBTA and BGEPA. Other agencies may also be called on for review and comment because of special expertise.

The National Wildlife Refuge System Administration Act (16 U.S.C. 668dd), as amended, serves as the “organic act” for the National Wildlife Refuge System. It consolidates the various categories of lands administered by the Secretary of the Interior (Secretary) through the FWS into a single National Wildlife Refuge System. The Act establishes a unifying mission for the Refuge System, a process for determining compatible uses of refuges, and a requirement for preparing comprehensive conservation plans. The Act states first and foremost that the mission of the National Wildlife Refuge System will be focused singularly on wildlife conservation.

The Act identifies six priority wildlife-dependent recreation uses; clarifies the Secretary’s authority to accept donations of money for land acquisition; and places restrictions on the transfer, exchange, or other disposal of lands within the Refuge System. Most importantly, the Act reinforces and expands the “compatibility standard” of the Refuge Recreation Act, authorizing the Secretary, under such regulations as he may prescribe, to “permit the use of any area within the System for any purpose, including but not limited to hunting, fishing, public recreation and accommodations, and access whenever he determines that such uses are compatible with the major purposes for which such areas were established.” This section applies to any proposed development of wind energy on Refuge System lands; such development must be compatible with the major purpose for which that Refuge was established.

The National Historic Preservation Act of 1966 (16 U.S.C. 470-470b, 470c-470n) approved October 15, 1966 and repeatedly amended, provides for preservation of significant historical features (buildings, objects, and sites) through a grant-in-aid program to the States. It established a National Register of Historic Places and a program of matching grants under the existing National Trust for Historic Preservation (16 U.S.C. 468-468d). The Act also requires Federal agencies to take into account the effects of their actions on items or sites listed or eligible for listing in the National Register. Thus, the Act functions similarly to NEPA, requiring a determination of the presence of any such items or sites, and an evaluation of the effects of proposed developments (such as wind energy facilities) on them, if the facility would be built, funded, licensed or permitted by a Federal agency. This includes State lands purchased or improved with Federal Aid in Wildlife Restoration funds.

Appendix 4

RESEARCH NEEDS ON THE IMPACTS OF WIND POWER DEVELOPMENT ON WILDLIFE

Representatives of the Fish and Wildlife Service’s Wind Turbine Siting Working Group have suggested the following research needs:

- Effects of inclement weather in attracting birds and bats to lighted turbines, e.g., drawing birds and bats to within rotor-swept area of turbines, particularly for passerines during spring and fall migrations.

- Localized effects of turbines on wildlife: habitat fragmentation and loss; effects of noise on both aquatic and terrestrial wildlife; habituation.

- Effects of wind turbine string configuration on mortality, e.g., end of row turbine effect, turbines in dips or passes or draws, setbacks from rim/cliff edges.

- Effectiveness of deterrents: alternating colors on blades (particularly, effect of black/white and UV gel coats on the smear effect); lights (e.g., color, duration, and intensity of pilot warning lights; lasers); infrasound (Breco Buoys, other noisemakers such as predator and distress calls if not irritating to humans, other wildlife, or domestic animals); visual markers on guy wires.

- Utility of acoustic, infrared, and radar technologies to detect bird species presence, abundance, location height, and movement.

- Accuracy of mortality counts: estimate of the number of carcasses (especially of passerines) lost because they have been fragmented and lost to collision momentum and the wind; size and shape of dead bird search areas; possibility of recording collisions acoustically or with radar or infrared monitoring.

- Annual variability (temporal and spatial) in migratory pathways; what is the utility of Geographic Information System to assess migratory pathways and stopovers, particularly for passerines and bats.

- Effectiveness of seasonal wind turbine shutdowns at preventing mortalities, including the feasibility of using “self-erecting” turbines that are easily erected and dismantled without cranes, and taking them down during critical periods such as migrations.

- Impacts of larger turbines versus smaller models.

- Changes in predator-prey relationships due to placing potential perching sites in prairie habitats.

Appendix 5

PROCEDURES FOR ENDANGERED SPECIES EVALUATIONS AND CONSULTATIONS

The Endangered Species Act (ESA) directs all Federal agencies to participate in endangered species conservation. Specifically, section 7(a)(1) of the ESA charges Federal agencies to aid in the conservation of listed species. Section 7 (a)(2) requires Federal agencies to consult with the Fish and Wildlife Service (FWS) to ensure that actions that they fund, authorize, permit, or otherwise carry out will not jeopardize the continued existence of any listed species or adversely modify designated critical habitats. The FWS has developed a handbook describing the consultation process in detail. It is available on the FWS web site at http://endangered.fws.gov/consultations. Consultation may be informal or formal, depending upon the presence of listed species and the potential for the proposed project to affect them.

Before initiating an action, the Federal action agency (the agency authorizing a specific action) or its non-Federal permit applicant, must ask the FWS to provide a list of threatened, endangered, proposed, and candidate species and designated critical habitats that may be present in the project area. This initiates the informal consultation process. If the FWS answers that no species or critical habitats are present, then the Federal action agency or permit applicant has no further ESA obligation under section 7(a)(2), and consultation is concluded. If listed species or critical habitats are present, then the action agency or applicant must determine whether the project may affect those species (known as a *may affect* determination), and informal consultation continues. If the action agency or applicant determines, and the FWS agrees, that the project does not adversely affect any listed species, then the consultation is concluded and the decision is put in writing.

If the action agency or applicant determines that a project *may adversely affect* a listed species or designated critical habitat, the action agency/applicant prepares a *Biological Assessment* and requests formal consultation. There is a designated period of time in which to consult (90 days), and beyond that, another set period of time for the FWS to prepare a *biological opinion* (45 days). An analysis of whether or not the proposed action would be likely to jeopardize the species or adversely modify its critical habitat is determined in the biological opinion. If a *jeopardy* or *adverse modification* determination is made, the biological opinion must identify any reasonable and prudent alternatives that could allow the project to move forward.

The biological opinion will contain an "incidental take statement." "Take" is defined as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting or attempting to engage in any such conduct. "Harm" is further defined to include significant habitat modification or degradation that results in death or injury to a listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. "Incidental take" is defined as take that is incidental to, and not the purpose of, an otherwise lawful activity. If the FWS issues a *jeopardy* opinion, the incidental take statement will simply state that no take is authorized. If the FWS issues a nonjeopardy opinion, the FWS will anticipate the take that may result from the proposed project and describe that take in the incidental take statement. The statement will contain clear terms and conditions designed to reduce the impact of the anticipated take to the species; these terms are non-discretionary on the action agency or applicant.

When non-Federal activities will result in take of threatened or endangered species, an *incidental take permit* is required under section 10 of the ESA. A habitat conservation plan or "HCP" must accompany an application for an incidental take permit. The habitat conservation plan associated with the permit is to ensure that there are adequate conservation measures to avoid jeopardy to the species.

Examples:

1. **No Effect** – The appropriate conclusion when the action agency or applicant determines that its proposed action will not affect a listed species or designated critical habitat.

   Example: A permit applicant contacts the FWS to request information on listed species. The FWS provides a species list containing 3 plants, 1 fish, and 1 butterfly. The proposed project would be constructed at an upland site on clay soils. The 3 plants are found only on sandy soils. The butterfly's habitat is one of the plants on sandy soil. The nearest sandy soils are 10 miles from the proposed project. The fish is in a stream 5 miles from the proposed project. Conclusion: No effects from the project, either

direct or indirect. Justification: No construction is proposed in listed species habitat or in an area that may affect listed species. In addition, the project proponent has charted a route for heavy equipment moving onto the construction site that avoids listed species habitat.

2. **May Affect, but Not Likely to Adversely Affect** – The appropriate conclusion when effects on listed species are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not (a) be able to meaningfully measure, detect, or evaluate insignificant effects, or (b) expect discountable effects to occur.

   Example: The applicant contacts the FWS to request information on listed species. The FWS provides a species list containing 2 birds and 1 fish. The proposed project would be constructed at an upland site, 200 yards from the stream (fish habitat) and adjoining riparian vegetation (bird habitat). The migratory birds use the riparian vegetation to nest between April 15 and August 15. The uplands are highly erodible soils. The project proponent agrees not to construct during the nesting season. He flags the riparian vegetation to indicate an avoidance zone and installs silt fencing between the riparian vegetation and the construction site. He states that he will plant the disturbed soils surrounding the project with native vegetation after construction. He also agrees to monitor the vegetation planted for 3 years to assure that it establishes sufficiently to prevent any additional erosion in the project area caused by construction. Conclusion: Although the project proponent is working in very close proximity to listed species habitat, the action is not likely to adversely affect listed species. Justification: The proponent has incorporated sufficient avoidance and other mitigation measures into the project that any effects to listed species would be discountable. The project proponent prepares a Biological Assessment that includes a complete description of the project, all proposed avoidance and other mitigation measures, and the resulting effects of the project on the listed species. The Biological Assessment is sent to the FWS to request concurrence that the project is not likely to adversely affect listed species.

3. **May Affect, and Likely to Adversely Affect –** The appropriate finding in a Biological Assessment (or conclusion during informal consultation) if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial. In the event the overall effect of the proposed action is beneficial to the listed species, but is also likely to cause some adverse effects, then the proposed action "is likely to adversely affect" the listed species. If incidental take is anticipated to occur as a result of the proposed action, an "is likely to adversely affect" determination should be made. This determination requires the initiation of formal section 7 consultation.

   Example: The applicant contacts the FWS to request information on listed species. The FWS provides a species list containing 10 birds. The proposed project would be constructed at an upland site within a significant migratory bird corridor that is utilized by the 10 listed birds. Construction will permanently alter the character of the corridor and will likely cause take of listed birds every year during the migration periods. Conclusion: Formal consultation will be required. The project proponent prepares a Biological Assessment to submit to the action agency to accompany their request to initiate formal consultation. Justification: The project is likely to cause take of listed birds every year during their migration periods.

Appendix 6

GUIDELINES FOR CONSIDERING WIND TURBINE SITING ON EASEMENT LANDS ADMINISTERED AS PART OF THE NATIONAL WILDLIFE REFUGE SYSTEM IN REGION 6

Grassland easements are acquired to protect native and planted grasslands essential for grassland dependent migratory birds and other wildlife. Healthy grasslands provide both nesting and migration habitat necessary to maintain these important populations. Wind energy could severely impact this important program if not developed carefully with as little impact to migratory birds and their habitat as possible.

The following guidelines are to be used when making compatibility determinations for the siting of wind turbines and associated facilities on lands encumbered by U.S. Fish and Wildlife Service (Service) grassland easements and USDA conservation easements administered by the Service in Region 6, particularly in North Dakota, South Dakota, and Montana. These guidelines are intended to provide guidance for considering compatibility determinations during the period while the Service and the wind power industry monitor potential impacts to migratory birds as a result of turbine construction, maintenance, and operation. The following guidelines will be incorporated into rights-of-way permits issued for the construction of turbines, access roads, and other associated activities necessary to make the turbines operational. The intention of these guidelines is to minimize impacts to migratory birds and protect the habitat covered by the easement. The guidelines pertain only to permits issued for the alteration or destruction of grassland habitat as a result of turbine and other associated construction on lands encumbered by Service easements.

Refuge Managers and Wetland District Managers shall use these guidelines for site-by-site consideration of compatibility determinations for individual right-of-way requests for wind turbines on easement lands. These guidelines may be incorporated as needed as right-of-way or permit stipulations.

These guidelines may be revised and modified as a result of the findings of research and monitoring conducted in the future. Wind turbine rights-of-way applications will be reviewed according to these guidelines in conjunction with the Service's compatibility policy and in accordance with 50 CFR 29.21 and the Service Realty Manual. Future right-of-way applications will be reviewed using the guidelines in effect at the time of application. The Service will not make changes to previously issued rights-of-way or easement permits issued under these guidelines.

1) The Service may permit up to one turbine per 160 acres on an individual easement tract. No more than one turbine may be allowed on an individual easement tract of less than 160 acres. Current biological information (Attachment 2) indicates that this density of turbines would not have any significant impact to grassland habitat and its value to migratory birds or other wildlife. This is the upper limit for the density of turbines on easements. However, consideration may be given to clump or consolidate towers within an easement tract(s) to minimize the disturbance to the remaining habitat, i.e., two turbines may be clumped on a tract of 320 acres. Information available at this time indicates that turbine densities at this level will not materially interfere with or detract from the purposes of the easement (Attachment 2). Wind power industry turbine spacing recommendations are 2,000 feet between wind turbines and 2,000 feet from an occupied building. This constraint may limit the ability to clump turbines.

2) Turbines shall not be constructed in wetlands, including lakes, ponds, marshes, sloughs, swales, swamps, or potholes. Similarly, turbine locations should avoid obvious "duck passes" between large (20 acres or greater), semi-permanent (type 4, or cattail/bulrush) wetlands or sloughs. In addition, known migratory bird corridors or flight paths and environmentally sensitive areas such as colonial bird nesting areas or upland game bird leks, should be avoided.

3) Siting recommendations made by the Service for turbines and access roads and turbine lighting recommendations shall be consistent with all general siting and mitigating measures for tower and transmission line construction (Director's September 14, 2000 memorandum, attachment 3, APLIC 1996, and APLIC 1994).

4) Priority should be given to siting turbines on tame, planted, or seeded grasslands in preference to unbroken native prairie when such options are available on a given easement tract.

5) Spoil material from the excavated turbine pad shall not be deposited in wetlands and must be stored or deposited off easement lands using established roads to transport the material off site.

6) Turbines shall be sited as close to existing roads or the edge of the grassland tract as practical. Disturbance of grassland to construct and maintain a wind turbine shall be done in such a manner as to minimize the destruction or alteration of the habitat. Use of existing roads as a means of accessing a turbine within protected habitats is strongly encouraged. Conservation measures shall be used to avoid the impacts of erosion and sedimentation in order to protect grasslands and wetlands during the construction of the access road. Buried transmission lines, electric lines, and other cables shall be co-located on the access road when practical. Turbine construction should be encouraged to occur outside the breeding season for migratory birds when practical.

7) Regardless of a Service permit the developer is responsible for adhering to all local, state, and federal regulations in siting turbine location and construction. In the event that location and construction criteria conflict between the various levels of government, the criteria providing the maximum protection to the habitat shall be the criteria used during turbine location and construction.

8) In the event that a turbine is no longer utilized for power generation and has been abandoned for that purpose, the turbine owner shall remove the turbine at his/her own expense from the easement tract. The turbine site and associated facilities shall be reclaimed by the turbine owner by planting these areas to a grass mixture consistent with the surrounding grassland or such mixture as is mutually agreed upon by the Service and the turbine owner.

9) The turbine owner must update bird strike avoidance equipment on turbines and implement techniques that reduce the disturbance to nesting birds at turbine sites as future research and evaluation by the Service and the industry indicate.

These guidelines provide flexibility for the Service Refuge Manager in evaluating compatibility determinations and to negotiate with the energy company and the easement landowner to allow wind turbine development consistent with the purposes of the conservation easements. Where development is found to be compatible with easement purposes the guidelines will be used to negotiate siting, lighting, and other restrictions to grant rights-of-way and easement permits for wind turbines.

References:

Avian Power Line Interaction Committee (APLIC). 1994. Mitigating bird collisions with power lines: The state of the art in 1994.

Avian Power Line Interaction Committee (APLIC). 1996. Suggested practices for raptor protection on power lines: the state of the art in 1996.

Attachment 2

Potential Effect of Wind Turbine Presence on Numbers of Breeding Grassland Birds and Nesting Ducks on Grassland Easement Properties in North and South Dakota.

Ron Reynolds, Project Leader, Habitat And Population Evaluation Team, Bismarck, North Dakota.
Neal Niemuth, Biologist, Habitat And Population Evaluation Team, Bismarck, North Dakota

Recently, companies that develop wind-powered electricity generation have begun operations in areas of South Dakota and North Dakota where the U.S. Fish and Wildlife Service has purchased or intends to purchase conservation easements on grasslands. Questions have been raised within the FWS as to whether the placement of wind towers on easement tracts would violate terms of the easement contract, and whether the Service would consider purchasing easements on lands after towers are in place. Before allowing turbines on easement lands, the Service must address the issue of whether placement of wind turbines on grassland easements is compatible with the

goals and purpose of refuge lands as defined by the Refuge Improvement Act, which states that, "A Compatible use means . . . any other use of a National Wildlife Refuge that, based on sound professional judgment, will not materially interfere with or detract from the fulfillment of the National Wildlife Refuge System mission or the purposes(s) of the National Wildlife Refuge." If birds avoid the area surrounding wind turbines because of noise, disruption of habitat, or disturbance, the biological value of an easement may be compromised. At this time, we do not know if wind turbines are compatible with the purpose of grassland easements, because we do not know if turbines reduce the attractiveness of a site to birds or if turbines affect avian reproductive success. The issue is complicated partly because, if, the FWS restricts certain alternative uses on easements, this may reduce the willingness of landowners to offer to sell easements to the FWS in the future. For example, some landowners believe the potential income derived from wind generators will exceed the income from selling grass easements to the FWS or other conservation organizations. In this respect, the future success of the easement program could be compromised if these restrictions are unnecessary.

Little is known about bird avoidance of grasslands near wind turbines, as previous avian research at wind towers has focused primarily on bird strikes. In one study that did consider avoidance, density of grassland birds was reduced in the immediate vicinity of wind turbines at Buffalo Ridge, Minnesota, (Leddy et al. 1999), although at larger scales no differences were detected (Johnson et al. 2000). However, in the Buffalo Ridge study, wind turbines were placed primarily in Conservation Reserve Program fields with few wetlands and much higher densities of breeding birds than are typically found in native prairie where grassland easements are targeted in the Dakotas, and therefore results from Leddy et al. (1999) may not be applicable here. In the absence of specific data on the effect of wind turbines on birds in North and South Dakota, we used two approaches to assess the potential impact; 1) existing data (Igl and Johnson 1997, D. H. Johnson, unpublished data) was used to estimate the potential impact of wind turbine placement on grassland bird use in quarter-section (160 acre) parcels, and 2) a Mallard productivity model (Cowardin et al. 1988) was used to predict changes in nesting and recruitment rate of ducks on grassland areas with wind turbines in place.

Grassland birds. For the first assessment, abundance of grassland birds, standardized to 160 acres of grassland habitat, was estimated from data gathered on 128 quarter sections in North Dakota during summers of 1992 and 1993 (Igl and Johnson 1997, D. H. Johnson, unpublished data). We estimated the potential impact of wind turbines at two scales representing a five-acre and two-acre loss of habitat for each wind tower, with one wind tower per quarter section. We estimated the two-acre potential area of impact as approximately 4 times the area of road and tower pad (Appendix 1); the five-acre area of impact was estimated using the 80-m reported zone of reduced bird density surrounding towers at Buffalo Ridge (Leddy et al. 1999, Appendix 1). For purposes of our analysis, we assumed that no grassland birds would be present in the area immediately surrounding the tower, which is a worst-case scenario, because (Leddy et al. 1999) showed that birds are present immediately adjacent to turbines, but at reduced densities. Thus, our methods guaranteed we would predict a reduction in birds using easements, however, our intent was to put this change into perspective relative to bird use on the entire easement. Given the high variance associated with the grassland bird data we used, it would be impossible to detect a statistically significant decrease in grassland bird numbers, because the lower 95% confidence limit for population estimates was less than zero for each species (D. H. Johnson, unpublished data). Therefore, we estimated the impact of tower presence by calculating the density of each grassland bird species per 160-acre tract, and then calculating the mean reduction in the number of pairs if 2 acre and 5 acre areas of habitat were considered as unused (Table 1).

Expected reductions were estimated at approximately 1% and 3% of the number of individuals present for each species. As expected, greatest reductions in number of pairs occurred with common species such as the chestnut-collared longspur and horned lark; where, at the 5 acres level, a reduction of less than 1 pair per 160-acre tract would be expected. For all species combined, we estimated the expected maximum reduction would be about 2 pairs per 160 acre area, or about 3 percent of the total population. As mentioned previously, based on variation observed in the existing data set, these levels of change would not be statistically significant. Additionally, because we would expect some bird use of the area near the tower, the actual change would likely be less than the numbers presented in table 1.

Table 1. Mean number of breeding pairs of grassland birds found per 160 acres of grassland and expected reduction in pairs with loss of 5 acres and 2 acres of habitat. Data based on surveys of 128 160-acre parcels in North Dakota during summers of 1992 and 1993 (Igl and Johnson 1997, D. H. Johnson, unpublished data).

	Mean Number (pairs)		Mean Reduction (pairs)	
Species	1992	1993	5 acre	2 acre
Baird's Sparrow	1.424	2.464	0.06075	0.0243
Bobolink	0.336	0.784	0.0175	0.007

Brewer's Sparrow	0	0	0	0
Brown-headed Cowbird	2.88	3.632	0.10175	0.0407
Chestnut-collared Longspur	15.584	19.696	0.55125	0.2205
Clay-colored Sparrow	2.08	1.92	0.0625	0.025
Common Yellowthroat	0.144	0.112	0.004	0.0016
Dickcissel	0.304	0.32	0.00975	0.0039
Ferruginous Hawk	0.032	0.24	0.00425	0.0017
Field Sparrow	0.24	0	0.00375	0.0015
Grasshopper Sparrow	6.368	8.928	0.239	0.0956
Gray Catbird	0	0	0	0
Gray Partridge	0.16	0.128	0.0045	0.0018
Horned Lark	6.88	12.544	0.3035	0.1214
Killdeer	0.544	0.848	0.02175	0.0087
Lark Bunting	8.416	4.16	0.1965	0.0786
Lark Sparrow	0.448	0.128	0.009	0.0036
Le Conte's Sparrow	0	0.192	0.003	0.0012
Northern Harrier	0.304	0.512	0.01275	0.0051
Red-winged Blackbird	1.616	1.248	0.04475	0.0179
Ring-necked Pheasant	0.16	0.368	0.00825	0.0033
Savannah Sparrow	1.184	2.144	0.052	0.0208
Sedge Wren	0.16	0	0.0025	0.001
Sharp-tailed Grouse	0.432	0.464	0.014	0.0056
Sharp-tailed Sparrow	0.032	0	0.0005	0.0002
Short-eared Owl	0.032	0.032	0.001	0.0004
Sprague's Pipit	0.256	0.576	0.013	0.0052
Swainson's Hawk	0.032	0.16	0.003	0.0012
Upland Sandpiper	1.52	1.552	0.048	0.0192
Vesper Sparrow	1.312	0.976	0.03575	0.0143
Western Meadowlark	7.088	11.184	0.2855	0.1142
SUM	**59.97**	**75.31**	**2.11**	**0.85**

Ducks. To assess the impact of wind turbines on ducks, we used the Mallard Productivity Model (Cowardin et al. 1988). The Mallard Model is particularly useful for this exercise because it allowed us to predict any "net" change in nest site selection and recruitment that might occur as a result of simulating the reduction of grasslands available to nesting hens due to the placement of wind turbines. For example, if grassland availability is reduced as a result of disturbance, displaced hens may select other habitat types (e.g., cropland, hayland etc.) in the area for nesting, or they may elect to nest elsewhere in the grasslands protected by easement. If other habitats are selected, this could result in reduced recruitment because, most other habitats are characterized by lower nest success compared to grass habitats. However, if these hens select nest sites in the remaining grasslands outside the influence of the wind turbines, nest success will not change materially and recruitment rate will be the same with-or-without turbines. For this exercise, we selected six study areas from Four Square Mile plots used for breeding population and production surveys (Cowardin et al. 1995) in the Kulm Wetland Management District in North Dakota. Plots were selected that had ≥160 acres of grassland in one unit, and were accessible to ≥60 breeding duck pairs (≥12 mallard pairs) based on the "thunderstorm map" (HAPET 2000) for North Dakota. These criteria are consistent with those used by FWS Realty Office, Bismarck, ND for focusing grassland easements, and the Kulm WMD is representative of areas where the grassland easement program is being targeted. For the purpose of our assessment, all grasslands on study plots selected were treated as protected by easement. This was done to obtain sample acreage similar to easement acreage being purchased. We ran the model on plots with-and-without wind turbines in place and compared the response by mallard hens. The area of influence for turbines was set at 5 acres and was converted to barren habitat which simulated eliminating all nesting activity in that area. To reduce variability, and thus increase the precision of our estimates we conducted eight model runs (1000 hens each) and then scaled the average results to the estimated mallard population on each study plot.

Neither nests initiated or recruitment rates differed significantly between treatment and control model runs (Table 2). The variation shown in nests initiated and recruitment rate between treatment and control runs is due to variation inherent in the biological system being examined. The model predicts that hens displaced by the presence of wind turbines will select nesting sites in the remaining available grass habitat and that recruitment rates will not be influenced.

Summary. Using data collected in North Dakota and South Dakota for grassland birds and ducks, we were able to estimate the magnitude of change that would likely be observed if similar data were collected on grassland easement properties. For some species of grassland birds that have restricted distributions the changes predicted could be underestimated on some sites, but it is unlikely these would be of a different order of magnitude. For ducks, the changes predicted account for differences in geographic distribution. Based on our assessment, the expected impact of wind turbines on grassland nesting species would be negligible with the density of one turbine per 160 acre area.

Table 2. Mallard nests initiated and recruitment rate estimates on six study plots with-and-without wind turbines, based on Mallard Model predictions. ( ) standard errors.

	Without Wind Turbines					With Wind Turbines			
Study plot	Pop. Estimate	Grass Acres	Init. Nests	Recr. Rate	SE	No. Turbines	Init.Nests	Recr. Rate	SE
153	55	761	21	0.67	(.0115)	2	21	0.64	(.0090)
178	60	205	14	0.53	(.0094)	1	13	0.52	(.0064)
329	45	1496	59	0.57	(.0055)	3	59	0.59	(.0124)
330	35	1810	51	0.55	(.0163)	8	52	0.55	(.0118)
331	26	1310	18	0.62	(.0104)	2	18	0.59	(.0120)
332	70	1312	58	0.58	(.0166	2	60	0.58	(.0072)

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Johnson, G. D., W. P. Erickson, M. D. Strickland, M. F. Shepherd, and D. A. Shepherd. 2000. Avian monitoring studies at the Buffalo Ridge, Minnesota Wind Resource Area: results of a 4-year study. Western Ecosystems Technology, Inc. Cheyenne, Wyoming. 262pp.

Leddy, K. L., K. F. Higgins, and D. E. Naugle. 1999. Effects of wind turbines on upland nesting birds in Conservation Reserve Program grasslands. Wilson Bulletin 111:100-104.

APPENDIX 1. Calculations of potential area of impact for wind towers on grassland easements in North Dakota and South Dakota.

Two-acre impact:

40 foot by 40 foot pad for tower		1,600 ft^2
16.5 foot by 1320 foot access road		21,780 ft^2
	total	23,380

Physical disruption of site is approximately 0.54 acre; we multiplied this by four to estimate a zone of potential impact.

Five-acre impact:
80-m zone of reduced density surrounding tower

80 m * 80 m * 3.14	2.0 ha
˜ 2.5 acres per ha	5.0 acres

Attachment 3

Memorandum

To: Regional Directors, Regions 1-7

From: Director

Subject: Service Guidance on the Siting, Construction, Operation and Decommissioning of Communications Towers

Construction of communications towers (including radio, television, cellular, and microwave) in the United States has been growing at an exponential rate, increasing at an estimated 6 percent to 8 percent annually. According to the Federal Communication Commission=s *2000 Antenna Structure Registry*, the number of lighted towers greater than 199 feet above ground level currently number over 45,000 and the total number of towers over 74,000. By 2003, all television stations must be digital, adding potentially 1,000 new towers exceeding 1,000 feet AGL.

The construction of new towers creates a potentially significant impact on migratory birds, especially some 350 species of night-migrating birds. Communications towers are estimated to kill 4-5 million birds per year, which violates the spirit and the intent of the Migratory Bird Treaty Act and the Code of Federal Regulations at Part 50 designed to implement the MBTA. Some of the species affected are also protected under the Endangered Species Act and Bald and Golden Eagle Act.

Service personnel may become involved in the review of proposed tower sitings and/or in the evaluation of tower impacts on migratory birds through National Environmental Policy Act review; specifically, sections 1501.6, opportunity to be a cooperating agency, and 1503.4, duty to comment on federally-licensed activities for agencies with jurisdiction by law, in this case the MBTA, or because of special expertise. Also, the National Wildlife Refuge System Improvement Act requires that any activity on Refuge lands be determined as compatible with the Refuge system mission and the Refuge purpose(s). In addition, the Service is required by the ESA to assist other Federal agencies in ensuring that any action they authorize, implement, or fund will not jeopardize the continued existence of any federally endangered or threatened species.

A Communication Tower Working Group composed of government agencies, industry, academic researchers and NGO=s has been formed to develop and implement a research protocol to determine the best ways to construct and operate towers to prevent bird strikes. Until the research study is completed, or until research efforts uncover significant new mitigation measures, all Service personnel involved in the review of proposed tower sitings and/or the evaluation of the impacts of towers on migratory birds should use the attached interim guidelines when making recommendations to all companies, license applicants, or licensees proposing new tower sitings. These guidelines were developed by Service personnel from research conducted in several eastern, midwestern, and southern States, and have been refined through Regional review. They are based on the best information available at this time, and are the most prudent and effective measures for avoiding bird strikes at towers. We believe that they will provide significant protection for migratory birds pending completion of the Working Group=s recommendations. As new information becomes available, the guidelines will be updated accordingly.

Implementation of these guidelines by the communications industry is voluntary, and our recommendations must be balanced with Federal Aviation Administration requirements and local community concerns where necessary. Field

offices have discretion in the use of these guidelines on a case by case basis, and may also have additional recommendations to add which are specific to their geographic area.

Also attached is a Tower Site Evaluation Form which may prove useful in evaluating proposed towers and in streamlining the evaluation process. Copies may be provided to consultants or tower companies who regularly submit requests for consultation, as well as to those who submit individual requests that do not contain sufficient information to allow adequate evaluation. This form is for discretionary use, and may be modified as necessary.

The Migratory Bird Treaty Act (16 U.S.C. 703-712) prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. While the Act has no provision for allowing an unauthorized take, it must be recognized that some birds may be killed at structures such as communications towers even if all reasonable measures to avoid it are implemented. The Service=s Division of Law Enforcement carries out its mission to protect migratory birds not only through investigations and enforcement, but also through fostering relationships with individuals and industries that proactively seek to eliminate their impacts on migratory birds. While it is not possible under the Act to absolve individuals or companies from liability if they follow these recommended guidelines, the Division of Law Enforcement and Department of Justice have used enforcement and prosecutorial discretion in the past regarding individuals or companies who have made good faith efforts to avoid the take of migratory birds.

Please ensure that all field personnel involved in review of FCC licensed communications tower proposals receive copies of this memorandum. Questions regarding this issue should be directed to Dr. Benjamin N. Tuggle, Chief, Division of Habitat Conservation, at (703)358-2161, or

Jon Andrew, Chief, Division of Migratory Bird Management, at (703)358-1714. These guidelines will be incorporated in a Director=s Order and placed in the Fish and Wildlife Service Manual at a future date.

Attachment

cc: 3012-MIB-FWS/Directorate Reading File
3012-MIB-FWS/CCU Files
3245-MIB-FWS/AFHC Reading Files
840-ARLSQ-FWS/AF Files
400-ARLSQ-FWS/DHC Files
400-ARLSQ-FWS/DHC/BFA Files
400-ARLSQ-FWS/DHC/BFA Staff
520-ARLSQ-FWS/LE Files
634-ARLSQ-FWS/MBMO Files (Jon Andrew)

FWS/DHC/BFA/RWillis:bg:08/09/00:(703)358-2183
S:\DHC\BFA\WILLIS\COMTOW-2.POL

Service Interim Guidelines For Recommendations On
Communications Tower Siting, Construction, Operation, and Decommissioning

1. Any company/applicant/licensee proposing to construct a new communications tower should be strongly encouraged to collocate the communications equipment on an existing communication tower or other structure (e.g., billboard, water tower, or building mount). Depending on tower load factors, from 6 to 10 providers may collocate on an existing tower.

2. If collocation is not feasible and a new tower or towers are to be constructed, communications service providers should be strongly encouraged to construct towers no more than 199 feet above ground level, using construction techniques which do not require guy wires (e.g., use a lattice structure, monopole, etc.). Such towers should be unlighted if Federal Aviation Administration regulations permit.

3. If constructing multiple towers, providers should consider the cumulative impacts of all of those towers to migratory birds and threatened and endangered species as well as the impacts of each individual tower.

4. If at all possible, new towers should be sited within existing “antenna farms” (clusters of towers). Towers should not be sited in or near wetlands, other known bird concentration areas (e.g., State or Federal refuges, staging areas, rookeries), in known migratory or daily movement flyways, or in habitat of threatened or endangered species. Towers should not be sited in areas with a high incidence of fog, mist, and low ceilings.

5. If taller (>199 feet AGL) towers requiring lights for aviation safety must be constructed, the minimum amount of pilot warning and obstruction avoidance lighting required by the FAA should be used. Unless otherwise required by the FAA, only white (preferable) or red strobe lights should be used at night, and these should be the minimum number, minimum intensity, and minimum number of flashes per minute (longest duration between flashes) allowable by the FAA. The use of solid red or pulsating red warning lights at night should be avoided. Current research indicates that solid or pulsating (beacon) red lights attract night-migrating birds at a much higher rate than white strobe lights. Red strobe lights have not yet been studied.

6. Tower designs using guy wires for support which are proposed to be located in known raptor or waterbird concentration areas or daily movement routes, or in major diurnal migratory bird movement routes or stopover sites, should have daytime visual markers on the wires to prevent collisions by these diurnally moving species. (For guidance on markers, see *Avian Power Line Interaction Committee (APLIC). 1994. Mitigating Bird Collisions with Power Lines: The State of the Art in 1994. Edison Electric Institute, Washington, D.C., 78 pp*, and *Avian Power Line Interaction Committee (APLIC). 1996. Suggested Practices for Raptor Protection on Power Lines. Edison Electric Institute/Raptor Research Foundation, Washington, D.C., 128 pp.* Copies can be obtained via the Internet at http://www.eei.org/resources/pubcat/enviro/, or by calling 1-800/334-5453).

7. Towers and appendant facilities should be sited, designed and constructed so as to avoid or minimize habitat loss within and adjacent to the tower “footprint”@ However, a larger tower footprint is preferable to the use of guy wires in construction. Road access and fencing should be minimized to reduce or prevent habitat fragmentation and disturbance, and to reduce above ground obstacles to birds in flight.

8. If significant numbers of breeding, feeding, or roosting birds are known to habitually use the proposed tower construction area, relocation to an alternate site should be recommended. If this is not an option, seasonal restrictions on construction may be advisable in order to avoid disturbance during periods of high bird activity.

9. In order to reduce the number of towers needed in the future, providers should be encouraged to design new towers structurally and electrically to accommodate the applicant/licensee’s antennas and comparable antennas for at least two additional users (minimum of three users for each tower structure), unless this design would require the addition of lights or guy wires to an otherwise unlighted and/or unguyed tower.

10. Security lighting for on-ground facilities and equipment should be down-shielded to keep light within the boundaries of the site.

11. If a tower is constructed or proposed for construction, Service personnel or researchers from the Communication Tower Working Group should be allowed access to the site to evaluate bird use, conduct dead-bird searches, to place net catchments below the towers but above the ground, and to place radar, Global Positioning

System, infrared, thermal imagery, and acoustical monitoring equipment as necessary to assess and verify bird movements and to gain information on the impacts of various tower sizes, configurations, and lighting systems.

12. Towers no longer in use or determined to be obsolete should be removed within 12 months of cessation of use.

In order to obtain information on the extent to which these guidelines are being implemented, and to identify any recurring problems with their implementation which may necessitate modifications, letters provided in response to requests for evaluation of proposed towers should contain the following request:

> "In order to obtain information on the usefulness of these guidelines in preventing bird strikes, and to identify any recurring problems with their implementation which may necessitate modifications, please advise us of the final location and specifications of the proposed tower, and which of the measures recommended for the protection of migratory birds were implemented. If any of the recommended measures can not be implemented, please explain why they were not feasible."

Appendix 7

KNOWN AND SUSPECTED IMPACTS OF WIND TURBINES ON WILDLIFE

While wind-generated electrical energy is renewable, emission-free, and generally environmentally clean (American Wind Energy Association [AWEA] unpubl. data, <http://www.awea.org>), it does have one significant downside -- rotor blades kill birds, especially raptors (Hunt 2002) and bats. Birds can strike the towers; electrocutions can occur if designs are poor; and wind farms may impact bird movements, breeding, and habitat use.

Wind turbine technology is not new to the United States. In the 1800s, Cape Cod supported over 1,000 working wind turbines (Ferdinand 2002). In the late 1930s, Vermont boasted the world's then-largest turbine, which was likely disabled by high winds due to design flaws. But wind turbine 'farms' and their impacts to birds are a recent phenomenon compared to power lines and communication towers, where mortality has been documented for decades or longer (Boeker and Nickerson 1975, Olendorff et al. 1981, APLIC 1994, APLIC 1996, Harness 1997, Ainley et al. 2001, Manville 2001). The problem in the U.S. surfaced in the late 1980s and early 1990s at the Altamont Pass Wind Resource Area, a facility then containing some 6,500 turbines on 73 mi^2 of gently rolling hills just east of San Francisco Bay, California (Davis 1995). Orloff and Flannery (1992) estimated that several hundred raptors were killed each year due to turbine collisions, guy wire strikes, and electrocutions. The most common fatalities were those of Red-tailed Hawks (*Buteo jamaicensis*), American Kestrels (*Falco sparvarius*) and Golden Eagles (*Aquila chrysaetos*), with fewer mortalities of Turkey Vultures (*Cathartes aura*), Common Ravens (*Corvus corax*), and Barn Owls (*Tyto alba*). The impacts of this wind farm were of most concern to the population of Golden Eagles, which was showing a "disturbing source of mortality" to a disproportionately large segment of the population (Southern Niagara Escarpment [WI] Wind Resource Area unpubl. report). More recent studies indicate that a model previously used to assess Golden Eagle mortality was defective, and that nonbreeding Golden Eagles representing a "floater" population were likely suffering less mortality based on a new model (Hunt 2002). Research continues at this time to further assess the impacts of Altamont turbines on raptors. The Altamont turbines are still estimated to kill 40-60 subadult and adult Golden Eagles each year, as well as several hundred Red-tailed Hawks and American Kestrels – a continuing concern for the FWS. Of the variety of wind turbines at the site, the smaller, faster moving, Kenetech-built, lattice-supported turbines caused most of the mortality. As part of a re-powering effort, these turbines are now being replaced with slower moving, tubular-supported turbines. While Europeans have used tubular towers almost exclusively, the U.S. has almost solely used lattice support, at least until recently (Berg 1996).

Colson (1995) indicated that some 16,000 wind turbines operated in California, making the State the largest concentration of wind energy development in the world. Since 1995, that statistic has changed. While California still boasts the greatest number of turbines in the U.S., many smaller turbines are being replaced by fewer but larger models. Worldwide, an estimated 50,000 turbines are generating power (AWEA unpubl. data; Ferdinand 2002), of which over 15,000 are currently in 29 states in the U.S. Turbine numbers are often difficult to track since statistics are generally presented in megawatts (MW) of electricity produced rather than number of turbines present. The latter statistic is of greater concern to ornithologists. In 1998, for example, Germany was the greatest producer with 2,874 MW of electricity produced by turbines, followed by the U.S. (1,884), and Denmark (1,450); (AWEA unpubl. data). While some project that the number of wind turbines in the U.S. may increase by another 16,000 in the next 10 years, current trends indicate an even greater potential growth. Although the U.S. presently produces less than 1% of its electrical energy from turbines – compared, for example, to Norway's 15% – 2001 was a banner year for U.S. turbine technology, doubling the previous record for installed wind production. Companies installed 1,898 turbines in 26 states, which will produce nearly 1,700 MW, at a cost of $1.7 billion for the new equipment (J. Cadogan, U.S. Department of Energy, 2002, pers. comm.). Over the past decade, wind power has been the fastest growing energy industry in the world. By 2020, the AWEA (unpubl. data) predicts that wind will provide 6% of this nation's electricity, serving as many as 25 million households. Enron Wind Corporation constructed some 1,500 of the 1,898 turbines installed in the U.S. in 2001. Although Enron is now bankrupt, General Electric purchased the company and is now producing wind turbines.

In March 2002, President Bush signed the Job Creation and Worker Assistance Act, extending the production tax credit to the wind industry for another two years. There are presently attempts in Congress to amend the reauthorization of this legislation for five or more years. However, even with a bright future for growth, and with low speed tubular-constructed wind turbine technology now being stressed, larger and slower moving turbines still kill raptors, passerines, waterbirds, other avian species, and bats. Low wind speed turbine technology requires much larger rotors, blade tips often extending more than 420 ft. above ground, and blade tips can reach speeds in excess of 200 mph under windy conditions (J. Cadogan, U.S. Department of Energy, 2002, pers. comm.). When birds

approach spinning turbine blades, “motion smear” – the inability of the bird’s retina to process high speed motion stimulation – occurs primarily at the tips of the blades, making the blades deceptively transparent at high velocities. This increases the likelihood that a bird will fly through this arc, be struck by a blade, and be killed (Hodos et al. 2001).

What cumulative impact these larger turbines will have on birds and bats has yet to be determined. Johnson et al. 2002b raised some concerns about the impacts of newer, larger turbines on birds. Their data indicated that higher levels of mortality might be associated with the newer and larger turbines, and they indicated that wind power-related avian mortality would likely contribute to the cumulative impacts on birds. Since little research has been conducted on the impacts of large land-sited and offshore turbines on birds and bats, this newer technology is ripe for research.

Howell and Noone (1992) estimated U.S. avian mortality at 0.0 to 0.117 birds/turbine/yr., while in Europe, Winkelman (1992) estimated mortality at 0.1 to 37 birds/turbine/yr. Erickson et al. (2001) reassessed U.S. turbine impact, based on more than 15,000 turbines (some 11,500 in California), and estimated mortality in the range of 10,000 to 40,000 (mean = 33,000), with an average of 2.19 avian fatalities/turbine/yr. and 0.033 raptor fatalities/turbine/yr. This may be a considerable underestimate. As with other structural impacts, only a systematic turbine review will provide a more reliable estimate of mortality. While some have argued that turbine impacts are small (Berg 1996), especially when compared to those from communication towers and power lines, turbines can pose some unique problems, especially for birds of prey. Mortalities must be reduced, especially as turbine numbers increase. In addition to protections under the MBTA, Bald and Golden Eagles are afforded protections under the ESA for the former and the BGEPA for both raptors. As strict liability statutes, MBTA and BGEPA also provide no provisions for unauthorized “take.” Wind farms can affect local populations of Golden Eagles and other raptors whose breeding and recruitment rates are naturally slow and whose populations tend to have smaller numbers of breeding adults (Davis 1995). Large raptors are also revered by Native Americans as well as by many others within the public. They are symbolic megafauna, and provide greater emotional appeal to many than do smaller avian species. Raptors also have a lower tolerance for additive mortality (Anderson et al. 1997). As with all other human-caused mortality, we have a responsibility to reverse mortality trends.

Until very recently, U.S. wind turbines have mostly been land-based. Perhaps following the European lead of siting wind turbines in estuarine and marine wetlands (van der Winden et al. 1999, van der Winden et al. 2000), and perhaps due to an assessment of a large number of potential offshore turbine locations in the U.S. (based on Weibull analyses of “good, excellent, outstanding, and superb” wind speed potentials [National Renewable Energy Laboratory 1987]), a new trend is evolving in North America. Several proposals for huge offshore sites are being submitted for locations on both Atlantic and Pacific coasts. These, at the very least, should require considerable research and monitoring to assess possible impacts to resident and migrating passerines, waterfowl, shorebirds, and seabirds. One site at Nantucket Shoals, offshore of Nantucket Island near Cape Cod, Massachusetts, is proposed by the Cape Wind Association to contain 170 turbines, many over 420 feet high, within a 25 mi^2 area (AWEA unpubl. data, Ferdinand 2002). What impacts this wind farm would have on wintering sea ducks and migrating terns, especially the Federally endangered Roseate Tern (*Sterna dougallii dougallii*), and on Northern Gannets (*Morus bassanus*), is unknown. The Long Island Power Authority is proposing a site offshore of Long Island, New York’s south shore, covering as much as 314 mi^2. Other sites are being proposed for Portland, Maine, and Lake Erie. The largest proposed wind farm in North America is being planned for a 50 mi^2 area between Queen Charlotte Island, BC, and Alaska. It is being designed to contain 350 turbines, many exceeding 400 feet in height. The potential for significant offshore turbine impacts on waterbirds is great, virtually no research has been conducted in the United States to quell these concerns, and finding carcasses at sea is very challenging.

Europe presently has 10 offshore wind projects in operation, producing over 250 MW of electricity (British Wind Energy unpub. data, www.offshorewindfarms.co.uk). Many other projects are currently under review. To avoid citizen concerns regarding the “not in my backyard” complex, most European turbines are sited offshore or in estuaries, away from immediate human development (Larsen and Madsen 2000). While Europe is well ahead of the United States regarding turbine research, their study results are still generally inconclusive (T. Bowan, FWS, 2003 pers. comm.). Collision mortality, while generally unknown, is believed to be small because birds appear to avoid offshore wind farms. There are exceptions, including for Whooper Swans (*Cygnus Cygnus*; Larsen and Clausen 2002) that are susceptible to turbine strikes in the early mornings and evenings, especially in inclement weather. The collection of carcasses at offshore sites is more challenging than for land-based turbines since nets generally must be used to collect carcasses, tides and weather affect collection, and fog is a frequent problem. While habitat loss is not believed to be a serious concern, its impacts continue to be assessed. Disturbance may be problematic since some species such as Common Eiders avoid wind farms and may not return to a coastal area for several years (Guillemette and Larsen 2002). Disturbance may lead to displacement, and turbines may serve as barriers to

seaduck movements. Only a few studies have been conducted in Denmark, the Netherlands, and Sweden, so further research is needed. Studies deal mostly with wintering species (Noer et al. 2000, Percival 2001, Langstron and Pullan 2002, Christensen et al. 2002, and Bruns et al. 2002).

In an attempt to begin addressing the bird mortality issue – and ancillary to this, the issue of ESA-listed bat strikes – the National Wind Coordinating Committee was created in 1994 as part of President Clinton's Global Climate Change Action Plan (Colson 1995). Shortly following the creation of the Committee, the Avian Subcommittee (now called the Wildlife Work Group) was formed, co-founded by the Service. In 1999, the Avian Subcommittee published a *Metrics and Methods* document to study turbine impacts on birds (Anderson et al. 1999). The document provides an excellent resource for conducting research on proposed and existing turbines and wind farms.

Appendix 8

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Appendix 4. Legacy I and Legacy II

PHASE I PROPOSAL: Department of Defense Strategy to Support a Multi-Agency Bat Conservation Initiative within the State of Utah

Abstract:

In recognition of the importance of DoD lands to the conservation of bats throughout the nation, a memorandum of understanding (MOU) was signed in October of 2006 to "develop a policy of cooperation and coordination between the DoD and Bat Conservation International (BCI)". Within the spirit and intent of this MOU we have developed this 2007 Legacy Program funding proposal which brings together five DoD Command Groups- Dugway Proving Ground (DPG), Hill Air Force Base (HAFB), Utah National Guard (UNG) - Camp Williams and Washington County, Deseret Chemical Depot (DCD), and Tooele Army Depot (TEAD). This group of Defense Department land managers has coordinated with the U.S. Bureau of Land Management, U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, U.S.D.A. Natural Resources Conservation Service, UT Division of Wildlife Resources (UDWR), UT Division of Oil, Gas, and Mining, UT Division of Parks and Recreation, Utah State University, The Nature Conservancy (TNC) , Southern Utah State University, Rocky Mountain Power, and Kennecott Utah Copper. This regionally comprehensive State of Utah group is proposing to coordinate deliverables from the funding of this grant with the Great Basin Bat Cooperative (GBBC) and the Utah Bat Working Group (UBWG).

The teaming of these entities as presented in this proposal will develop a set of contract deliverables which 100% supports military test and training ranges and sound stewardship initiatives throughout Utah. Through this initiative we will collect, compile and analyze existing data on Utah bats as a critical element of a state-wide Bat Conservation Strategy.

Specifically we are proposing to-

1) identify distribution, quantity, and quality of existing data on suitable bat habitat in Utah within the AOR of the GBBC and UBWG (e.g. federal, state, and private land),
2) create a geodatabase that will track suitability of landscape characteristics that promote or limit potential use by bats (this database will identify what data exists and what data is lacking thereby allowing federal, state, and private land managers to collaboratively work together to target data gaps),
3) serve as a foundation for future cooperative bat research and management efforts in the state, and
4) collect bat species occurrence data within DoD managed lands supported by the GBBC and UBWG (this approach will be directed by high priority areas identified in the critical bat habitat model).

Once information is compiled and analyzed in conjunction with the GBBC and UBWG, DoD land managers will assist with the generation of conservation and management initiatives covering much of the State, but specifically emphasizing DPG, HAFB, TEAD, DCD, and UNG testing and training ranges. This forward-looking approach will enhance DoD's ability to access, evaluate, and utilize existing inventory data to manage bat species on military lands. Currently, Endangered Species Act (ESA) listed bat species do not occur in Utah, however 30 percent of Utah bat species are listed on the State and BLM sensitive species list (designated species of concern). Wildlife species of concern are those species for which there is credible scientific evidence to substantiate a threat to continued population viability. It is anticipated that wildlife species of concern designations will identify species for which conservation actions are needed, and that timely and appropriate conservation actions implemented on their behalf will preclude the need to list these species under the provisions of the federal ESA (UDWR 2004 Utah Sensitive Species Publication). This project is instrumental in assisting the ability of DoD land managers to support and approve DoD testing and training activities and will allow local decision authority to analyze and implement sound environmental decisions as we strive daily to meet readiness needs on the west desert.

Background:

This proposal brings together five Defense Department facilities within the State of Utah to form a collaborative partnership supporting the initiatives of the state's bat working groups, which in turn, are comprised of 14 other federal, state and private stakeholders. The results of this extensive collaborative effort will benefit the military test and training ranges and will support sound stewardship initiatives within the state of Utah on Defense Department lands.

The DoD military lands in Utah comprise several different specific missions but all depend on the availability and sustainability of testing and training lands. DPG (798,214 acres) is a major range and testing facility and the primary chemical and biological defense testing center under the Reliance Program . TEAD (23,610 acres) provides America's joint fighting forces with munitions and ammunition equipment in support of military missions before, during and after any contingency. DCD's main mission is

to destroy 45% of the US stockpile of chemical weapons and the Utah National Guard at CW (28,000 acres) provides quality training lands for the Utah National Guard and others. Finally, HAFB (968,774 acres) is home to many operational and support missions with Ogden Air Logistics Center, who provides worldwide engineering and logistics management. These five DoD partners control a substantial amount of land in Utah. Together they comprise 1,818,958 acres that contain significant bat habitat where little research has been carried out to determine the extent of use by bats or the ecology and biology patterns within the Great Basin. As a result, DoD land managers do not have a good idea of what bat species exist on their training and testing lands.

To further the problem, not only do DoD land managers lack an understanding of Utah bats, but state, federal, and private land holders do as well. A recent exhaustive review of bat research indicates that little information is available regarding the basic ecology of Utah's bat species, including data on population dynamics and trends, roost site selection, foraging behavior, reproduction, and migration (Oliver 2000). Existing data on habitat selection and resource use are poorly consolidated and scattered among federal, state, private and university information holdings making it difficult to identify and address statewide management issues related to the conservation of bats (Fenton 1997). In addition to the management and conservation problems created by sparse data is the potential for significant amounts of habitat loss resulting from human population growth and land development. The census, conducted by the U.S. Census Bureau in 2000, identified Utah as having the fourth fastest growing population in the nation, increasing by almost 30 percent between the years 1990 and 2000. Utah's rapid development combined with the high species diversity of bats has created a situation where six of the eighteen bat species, or 30 percent, are listed as state of Utah sensitive species of special concern.

Approach:

The lack of research on bat habitat and ecology in Utah and the degree of difficulty in accessing existing information on Utah bats is at a stage right now that will only contribute further to the bat's population decline and possible listing. Currently the UDWR is writing a Utah specific Bat Conservation Strategy and creating, with TNC, a Critical Bat Habitat Suitability Model. A critical element needed to support and validate these projects, is a DoD proposal that will complete a state-wide effort to manage Utah bats at a sufficient level to ensure a stable Utah population. This DoD proposal, if funded by the Legacy Program, will accomplish the four objectives outlined in the Abstract.

Identifying existing data will entail an exhaustive search for information held by federal and state agencies, universities, local contractors, private researchers, and non-profit groups located in Utah. All data sets obtained through this process will be entered into a geospatial database designed specifically for this effort. The database will be characterized by data masks and filters to ensure data quality, customizable user queries to facilitate data sorting and extraction, and the capability of becoming web enabled. The completed database will reside within and be maintained in perpetuity by the UDWR's Natural Heritage Program (NHP). In addition to providing a central location for partners to access and update Utah's bat inventory data beyond the life of this initiative, housing the database within the NHP will provide it with formidable data protection measures to prevent sensitive aspects of the data set from being released inadvertently.

Without this geospatial database, future research will suffer from a lack of understanding and knowledge of Utah habitat distribution and will only aggravate the problem of data scatter among federal, state, and university research groups. The proposed database will both be used as a foundation for future bat conservation efforts in Utah and provide context for historical datasets collected across a diversity of temporal and spatial scales. Although the geodatabase is a completely functional product on its own, through this project it will be nested within a much farther reaching conservation effort encompassing DoD installations as well as other public and private lands in Utah

Benefits to Military:

The DoD is a major user of west desert test and evaluation lands within the state of Utah. DoD requires continued access to those lands to maintain mission readiness. These lands support biological and chemical test and evaluation operations, munitions testing, deployment of weapon systems, and combat training exercises. The Utah Test and Training Range supports the evaluation of missile weapon systems and utilizes the largest joint contiguous CONUS airspace block to train pilots on air-based weapons systems. National Guard units conduct live fire exercises on Camp Williams and DPG ranges. In addition, these desert climates are utilized by large, mechanized, mobile training units to simulate real-time battle conditions. Throughout these lands, specific landscape characteristics and the intrinsic natural features are crucial to military readiness.

Conservation efforts ensure that these training environments are not degraded over time and that DoD has continued access to west desert testing ranges, impact areas, and testing grids. This legacy proposal directly supports this end through a sound set of biologically based initiatives designed to enhance the sustainability and usability of training and testing lands within the state of Utah. The effectiveness of this proposal is highlighted by the inclusion of every single military command in Utah with over 1.8 million acres of test and training lands (98% of DoD Utah land holdings). Extensive efforts have occurred to secure this support. We believe this regional approach to managing bats within the State of Utah and specifically understanding regional trends and patterns on DoD land 100% supports stewardship objectives and goals fundamental to sound land management policies within the Defense Department. More importantly, this proposal has a tangible benefit. It will benefit the military through the identification and description of state-wide data

currently existent within dozens of separate locations. This data, individually, is thought to be of marginal quantity and consistency, but collectively, within a state-wide database, will yield invaluable trends and patterns throughout DoD training ranges and state and private recreation lands. Funding this project will organize the existing data through the key project supported contract deliverables. Specifically this Legacy Program proposal will-

1. Create a geodatabase with federal, state, and private land managers that will track suitability of landscape characteristics that promote or limit potential use by bats;
2. Identify what data exists and what data is lacking thereby allowing land managers to collaboratively work together to target data gaps;
3. Serve as a foundation for future cooperative bat research and management efforts in the state of Utah;
4. Collect bat species occurrence data within the 1.8 million acres of DoD managed lands supported by the GBBC. This approach will be directed by high priority areas identified in the critical bat habitat model which is controlled by the UDWR (the main DoD partner for this proposal);
5. Increase understanding of Utah bat issues that may pose encroachment problems within DoD training lands and limit ability to meet mission requirements. Threats may arise if a petition to list State of concern status species was started (currently 6 of 18 bat species are state of concern); and
6. Substantially benefit the military through better understanding of the biological needs of bats which directly promotes sound stewardship initiatives developed cooperatively between State wildlife and DoD land managers.

As Utah DoD land managers strive to deal with the challenges of balancing land and air resources within a very high operational tempo, an understanding of the biological status on 18 species of bat is critical . Further, the overall collaborative efforts we have facilitated with 14 key stakeholders (within over 50 separate state, private, and government offices) will enhance military readiness and overall training needs to prepare the finest war fighters anywhere to meet mission needs and objectives.

Department of Defense Strategy to Support a Multi-Agency Bat Conservation Initiative Within the State of Utah

Project # 07-346

PHASE II PROPOSAL: Utah's Collaborative Bat Initiative Targeting INRMP and State Wildlife Action Plan Coordination through Habitat Modeling, Conservation Objective Development, Data Manipulation, and Regional and State Working Group Coordination

Abstract:

In recognition of the importance of DoD lands to the conservation of bats throughout the nation, a memorandum of understanding (MOU) was signed in October of 2006 to "develop a policy of cooperation and coordination between the DoD and Bat Conservation International (BCI)". Within the spirit and intent of this MOU we have developed this 2008 Legacy Program funding proposal which brings together five DoD Command Groups – Dugway Proving Ground (DPG), Hill Air Force Base (HAFB), Utah National Guard (UNG) - Camp Williams and Washington County, Deseret Chemical Depot (DCD), and Tooele Army Depot (TEAD). This group of Defense Department land managers has coordinated with the U.S. Bureau of Land Management (BLM), U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), National Park Service (NPS), U.S.D.A. Natural Resources Conservation Service (USDA), UT Division of Wildlife Resources (UDWR), UT Division of Oil, Gas, and Mining (DOGM), UT Division of Parks and Recreation, Utah State University (USU), The Nature Conservancy (TNC), Southern Utah State University (SUU) , Rocky Mountain Power, and Kennecott Utah Copper. Through the Bonneville Basin Conservation Cooperative (B2C2) and Utah Bat Conservation Cooperative (UBCC) this group of partners coordinated extensively to complete the FY2007 Legacy Proposal (#07-346) that created the Utah Bat Database (UBD), a comprehensive database managing all bat data in Utah and the Important Bat Habitat Model (BHM) which ranks and spatially identifies areas most suitable for a diversity of bats in the state of Utah using expert opinion in lieu of occurrence data. Future action to be coordinated through these groups is the integration of conservation objectives and plans over all the land managing agencies. This proposal would work with these groups to integrate existing Integrated Natural Resource Management Plan (INRMP) and State Wildlife Action Plan (WAP) goals and objectives throughout the state to ensure coverage for all 18 species of Utah's bats and in particular its 6 sensitive bat species. Data gathered through this proposal will be provided to the 5 DoD installation NR Managers for incorporation within existing INRMPs as part of the mandatory 1-year update process. This team of regionally comprehensive State of Utah partners is proposing to coordinate deliverables from the funding of this grant through the UBCC, B2C2, Range Environmental Group, and policy level managers within the Utah Test and Training Range group. With the support of the 2007 Legacy Program grant (DoD Proj # 07-346), the UBD was created as step one in a 3-part process focused on developing a comprehensive bat conservation program for Utah. This 2008 proposal will serve as the second year of an ongoing collaborative partnership effort to cooperatively manage 18 species of bats at state-wide level, 100% inclusive of all DoD lands within the State of Utah . Cumulative benefits of the analysis of the UBD's contents and its application to state cooperative efforts include the greater use, applicability, and therefore long-term value of the UBD deliverable from 2007. We propose to complete six main objectives-

1) Work with regional and state-wide partners to integrate existing Integrated Natural Resource Management Plans' (INRMPs) and the State Wildlife Action Plan's (WAP) goals and objectives throughout the state to facilitate mutually beneficial aspects for all 18 species of bat,

2) With the help of national bat experts, create a statistically-defensible data collection protocol based on conservation objectives (currently lacking) that will be implemented in all regions of the state to standardize bat data collection, improve usability and comparability of data, and address future listing concerns,

3) Create measurable conservation objectives to address data vulnerabilities identified during the data gap analysis of the Legacy funded Utah Bat Database (UBD) and the risk and threats assessment in Utah' s WAP,

4) Conduct an analysis of the populated UBD (creation was funded by Legacy Proj #07-346 funded) to identify data gaps potentially inhibiting development of conservation strategies for Utah's 18 species of bats,

5) Update and improve upon the state's existing Important Bat Habitat Model (v 2.0, BHM) to incorporate data stored in the UBD, and

6) Cooperate with State in integrating INRMP Range and Test Grid sustainability and management objectives within a jointly funded Utah Bat Conservation Plan. This document will be approved by the state Wildlife Board and RAC process and will contain conservation objectives, protocol, and an innovative State of Bats report that addresses all known information and data vulnerabilities for each species based on the UBD data gap analysis.

Background:

The DoD military lands in Utah comprise several different specific missions, but all depend on the availability and sustainability of testing and training lands. DPG (798,214 acres) is a major range and testing facility and the primary chemical and biological defense testing center under the Reliance Program . TEAD (23,610 acres) provides America’s joint fighting forces with munitions and ammunition equipment in support of military missions before, during and after any contingency. DCD’s main mission is to destroy 45% of the US stockpile of chemical weapons and the Utah National Guard at CW (28,000 acres) provides quality training lands for the Utah National Guard and others. Finally, HAFB (968,774 acres) is home to many operational and support missions with Ogden Air Logistics Center, who provides worldwide engineering and logistics management and operates in the Military Operating Area (MOA) with approximately 10,723,079 acres of airspace. These five DoD partners control a substantial amount of land in Utah. Together they comprise 1,818,958 acres that contain significant bat habitat where little research has been carried out to determine the extent of use by bats or the ecology and biology patterns within the Great Basin. As a result, DoD land managers do not have a good idea of what bat species exist on their training and testing lands. This project is focused on the usability and sustainability of DoDs testing and training lands to support our country’s war fighters in all times of need. To further the problem, not only do DoD land managers lack an understanding of Utah bats, but state, federal, and private land holders do as well. A recent exhaustive review of bat research indicates that little information is available regarding the basic ecology of Utah’s bat species, including data on population dynamics and trends, roost site selection, foraging behavior, reproduction, and migration (Oliver 2000). Existing data on habitat selection and resource use were, until recently (more below) poorly consolidated and scattered among federal, state, private and university information holdings making it difficult to identify and address statewide management issues related to the conservation of bats (Fenton 1997). In addition to the management and conservation problems created by sparse data is the potential for significant amounts of habitat loss resulting from human population growth and land development. The census, conducted by the U.S. Census Bureau in 2000, identified Utah as having the fourth fastest growing population in the nation, increasing by almost 30 percent between the years 1990 and 2000. This population explosion may be creating island oases for Utah bats on remote DoD installations and surrounding lands as natural, native habitat is taken over by developing cities and expanding human populations. Utah’s rapid development combined with the high species diversity of bats has certainly created a situation where six of the eighteen bat species, or 30 percent, are listed as state of Utah species of concern. Currently, Endangered Species Act (ESA) listed bat species do not occur in Utah, however the fact that 30 percent of Utah bats species are of sensitive status creates a large concern for not only the state but DoD land managers. It is our team’s belief that instituting proactive conservation actions and planning measures now will prevent more economically, politically, and biologically costly solutions in the future.

These facts led to the writing of a Legacy Program proposal in FY 2007 (#07-346). The FY 2007 Legacy grant received by Dugway Proving Ground in 2007 funded a now completed geodatabase (UBD) that has been populated with all known bat data in Utah. This database, although a functional product on its own, can serve a much greater function with an analysis of its content (this submittal). Such an analysis would provide direction to bat management and allow for the greater use and applicability of the database. The UBD involves a user-friendly online interface and solicited Utah data from regional partners. Over 12,000 records previously lost to the bat research community at large were obtained and used to populate the UBD. Organizations that have contributed data and support the UBD and its mission of data consolidation for the better management of sensitive bat species throughout the State are - UDOGM, UDWR (5 of 5 regions), the USFS (Spanish Fork Ranger District, Sawtooth NF, Wasatch-Cache NF, Fish Lake NF, Dixie NF, and Manti-LaSal NF), BLM (10 of 10 Field Offices and the Grand Staircase Escalante National Monument), contracting/consulting firms (SWCA and JBR), academics/researchers (Utah State University, Southern Utah University, Weber State University, Brigham Young University, and University of Utah’ s Natural History Museum), and 5 DoD installations. Specific and binding data use agreements are in place to protect data from exploitation but will encourage the use and meta-analysis of data by all parties. This six-step Legacy proposal will continue the work started last year (Legacy funded UBD FY2007), will enhance DoD’s understanding of the status of 18 species of bats in Utah, will lead the way in creating measurable conservation objectives for the 6 species currently designated as state sensitive, and provide the funding to work with national experts and regional working groups to provide Utah partners with standardized survey protocols. An understanding of bat population status coupled with established, statistically based data collection protocols and a state-wide database for data consolidation will allow DoD land managers to make educated decisions about command liability without extensive, exhaustive, and expensive surveys. Regional and state-wide knowledge of population health will allow DoD managers to approve and support testing and training activities with minimal input or survey work for bats with increasing or stable populations. For those species whose populations are declining, early detection, action and management of species on DoD lands will allow the continued use of testing and training areas without restrictions. If declining populations are managed on a state-wide level, DoD activities will not

have a significant impact on population stability with proper coordination with state and federal agencies and members of the Bonneville Basin Conservation Cooperative (B2C2) and Utah Bat Conservation Cooperative (UBCC).

Approach:

With the success of the Legacy FY07 #07-346 project, DoD managers and Utah Department of Wildlife Resource (UDWR) biologists are teaming up again to take the next step in implementing a comprehensive conservation strategy for Utah's bats. The most fundamental, and relatively easy, part of species management is figuring out what is known about a species. Perhaps the hardest, most difficult step is what we are now proposing. Although our summary of known data is complete, we now need to identify what information we don't have and how to remedy those shortfalls. This requires the creation of a process that will systematically fill these data vulnerabilities and standardize data collection so that these information deficits are specifically addressed within the scope of measurable, partner initiated conservation objectives.

The six objectives outlined in the Abstract will be completed through a three-step approach - Data Mining, Protocol Development, and Outreach – each is discussed separately below.

Step one, Data Mining, clearly defines what we know and where we are going. This step will involve the creation of a State of Bats Report (SBR), a gap analysis, and the creation of measurable conservation objectives. All three of these items will comprise separate chapters in the Utah Bat Conservation Plan (discussed in step two – Protocol Development below) and will be developed by the Project Lead (individual to work exclusively on Legacy grant efforts) with UBCC partner participation using the data stored in the Legacy funded Utah Bat Database (UBD).

The data in the database will be used to draw conclusions/assessments of bat distribution (by county/military base/land ownership, sex, species, breeding status, and relative abundance) to include positive and negative occurrences and maps for each species for the SBR. The SBR will also include analyses of 1) habitat associations calculated with a Spatial Data Modeler that uses a weights-of-evidence analysis, 2) Important Bat Habitat Model version 2.0, built using results from the weights-of-evidence analysis, 3) correlation of known diversity indices (from UBD datasets) with Important Bat Habitat Model, v . 2.0, 4) analysis of species occurrence relative to elevation gradients, 5) relative abundance of species by site, 6) mapping of subterranean data with buffered maternity and winter roost locations, 7) accounting of survey effort over time with species saturation curves by county, 8) define breeding season status and map breeding range by species, and 9) investigate the relationship between temperature and bat activity . The gap analysis will identify 1) habitats, elevation bands, and land ownerships that are under-represented in the data, 2) locations or areas where we have data vulnerabilities/gaps, and 3) deficiencies in life history information by species (roost locations, breeding ecology, migration corridors), and 4) survey effort deficiencies and trends across time and geography.

The last phase of Step One will be the creation of measurable conservation objectives. This will take place at a state-wide meeting of UBCC participants that will represent all involved land management agencies and conservation entities in Utah (DoD, USFWS, UDWR, UDOGM, BLM, NPS, USFS, TNC). Utah' s conservation objectives will be developed using established Conservation Action Planning (CAP) and SWOT (Strength, Weakness, Opportunity, and Threat) methodologies. A review and consideration of regional and national objectives will take place to insure consistency between Utah objectives and other objectives of regional and national organizations and agreements to include the Western Bat Working Group, NABCP (North American Bat Conservation Partnership), the Pacific North West Bat Grid Team (USFS Pat Ormsbee), and the Memorandum of Understanding (MOU) between Bat Conservation International (BCI) and the DoD.

Most importantly, these objectives will develop consistency amongst and between DoD's INRMP's, the State Wildlife Action Plan (WAP), and efforts throughout the bat research community nationwide. Working towards the same goals and objectives will lead to a faster and more efficient management of bat populations that will surpass any one organization's attempts at managing species populations. This is a win win approach for DoD in the state of Utah!

Step two, Protocol Development, provides the mechanism for how to get where we want to go. The majority of this development will take place at a facilitated workshop hosted by DoD and UDWR. National experts in statistics, survey design, regional biology, field biology, and bats will be invited to review existing national and regional protocols and customize them to fulfill Utah's predefined needs and vulnerabilities. Each invited participant will receive pre-workshop materials that will include the measurable conservation objectives created in Step One and survey protocols previously created for bat data collection in other western states. Development of the survey manual will be directed by the Project Lead and will be the written using results of the SME workshop. This protocol and manual – to be placed on the website created with Legacy funding in FY07 – will outline how to implement the official, statistically defensible, objective based bat data collection protocol of Utah by containing detailed instructions, bat species keys for identification, datasheets, materials and equipment descriptions, staffing expectations, ANABAT station design and development, and an ANABAT call analysis key.

The final part of Step Two will be the writing of a Utah Bat Conservation Plan. The writing of this plan, in fulfillment of the Utah WAP and DoD INRMPs, will be funded with Legacy and State ($5,000) monies. It will include the previously mentioned SBR, Gap Analysis, and conservation objectives with the developed Utah Protocol as an appendix. Key pieces of the plan will be integrated into the major DoD INRMPs in the state to ensure cooperative and consistent management between state and federal lands to the major benefit of the species. Finally, this Plan will provide state-wide, long-term guidance for bat research and monitoring and conservation measures for the state while identifying threats, risk, and solutions.

Step three, Outreach, will allow the information and knowledge gained from this project to reach all land management agencies, universities, conservation organizations, and the private sector in Utah. Utah Bat Conservation Plan implementation will be undertaken by the UDWR and DoD. Other management agencies, due to their ongoing involvement with the data collection process for the UBD and their input into state conservation objectives and protocol development, will support the Plan and its measurable objectives. The Plan and everything that goes into it will be presented at several meetings/conferences to include the National Military Fish and Wildlife Association, The Wildlife Society (local and national chapter), and working groups throughout the state. Members of the Bonneville Basin Conservation Cooperative (B2C2), representing the USFWS, HAFB, DPG, UDWR, and BLM will spread the use of the Plan through outreach and coordination. Finally, the Plan will be available to anyone on the 2007 funded DoD Legacy bat website for use by all land managers and bat researchers in the state.

Primary personnel for this project have coordinated with Pat Ormsbee of the Pacific Northwest U.S. Forest Service in Oregon. Through several phone conferences, constructive dialog and open communication between parties has guaranteed the free exchange of information and technologies. All participants mutually decided that the state of Utah and DoD land managers need to asses the newly acquired data acquisitions (from the Legacy FY07 funded effort), assess vulnerabilities, and design measureable objectives with its partners that are unique to Utah and state-specific data vulnerabilities to, ultimately, fulfill the state WAP and DoD INRMPs. Our current initiative will include extensive efforts to communicate and coordinate with national bat experts and the research community to insure consistency with other bat programs if they address Utah specific conservation objectives (including Pat Ormsbee's Bat Grid). Future efforts, however, could include a full collaboration between the Pacific Northwest bat group and our Utah efforts. This year's funded effort and last years successful award, positions Utah to be a fully active partner in regional and national conservation initiatives. We will have defined our own priorities and be able to participate fully and extensively with larger efforts like Pat Ormsbee's.

Accomplishment of what we have proposed will provide the State of Utah with a cooperatively created Utah Bat Conservation Plan sufficient to manage all 18 species of bat in the state. Land management agencies will use the Plan to manage land-owner-specific populations because it will be an effective state-wide plan created and developed by local biologist and national experts. Utah and bats could serve as one of the first examples of how entire taxa can be managed consistently over multiple ecosystems, not just within boundary lines and ownership signs. The Department of Defense will benefit from increased understanding of population trends and management and will be able to continue to support testing and training in areas where sensitive bat species may exist. Joint management will aid in the prevention of any ESA listing of bat species thereby producing an overall cost savings for the Defense Department as well as other state and federal agencies.

Military Benefits:

The DoD is a major user of west desert test and evaluation lands within the state of Utah. DoD requires continued access to those lands to maintain mission readiness. These lands support biological and chemical test and evaluation operations, munitions testing, deployment of weapon systems, and combat training exercises. The Utah Test and Training Range supports the evaluation of missile weapon systems and utilizes the largest joint contiguous CONUS airspace block to train pilots on air-based weapons systems. National Guard units conduct live fire exercises on Camp Williams and DPG ranges. In addition, these desert climates are utilized by large, mechanized, mobile training units to simulate real-time battle conditions. Throughout these lands specific landscape characteristics and intrinsic natural features are crucial to military readiness as many parts of Dugway Proving Ground and Hill Air Force Base look very much like countries in the Middle East. As Utah DoD land managers strive to deal with the challenges of balancing land and air resources within a very high operational tempo, an understanding of the biological status on 18 species of bat is critical. Further, the overall collaborative efforts we have facilitated with 14 key stakeholders (with over 50 separate state, private, and government offices) will enhance military readiness and overall training needs to prepare the finest war fighters anywhere to meet mission needs and objectives.

Conservation efforts ensure that training environments are not degraded over time and that DoD has continued access to west desert testing ranges, impact areas, and testing grids. This legacy proposal directly supports this end through a sound set of biologically based initiatives designed to enhance the sustainability and usability of training and testing lands within the state of Utah. The effectiveness of this proposal is highlighted by the inclusion of every single military command in Utah with over 1.8 million acres of test and training lands (98% of DoD land holdings in Utah). Extensive efforts have occurred to secure this support. We believe this regional approach to managing bats within the State of Utah and specifically understanding regional trends and patterns on DoD land 100%

supports stewardship objectives and goals fundamental to sound land management policies within the Defense Department. More importantly, this proposal has a tangible benefit. It will benefit the military through the identification and description of needed data for Utah bats. Through the analysis of data gaps of the Legacy funded 2007 UBD, extensive knowledge will be gained about what is unknown and what needs to be known in order to manage and prevent the listing of any of the 18 species of Utah bats. This information will yield invaluable information and will allow the continued use of DoD training ranges through the pro-active, early detection of any decline in populations of Utah bats. Most importantly, management of declining bat populations on surrounding lands will help improve Mission usability of bat habitat on DoD lands. If known existing bat habitat adjacent to military lands is known to house state sensitive species then mission essential tasks will not be limited by existing habitat on DoD lands. By collaboratively managing bats, DoD land managers can be assured that the BLM, USFS, UDWR, and other land holders surrounding military lands are doing their part to manage for species that could effect mission and essential testing and training activities on DoD lands. If all agencies manage for species that could effect mission readiness then military land managers can be assured that at some point in the future, DoD property will NOT be the sole location and oasis for Endangered Species Act threatened and endangered species that so many DoD installations throughout the United States have become.

Appendix 5. Field key for bats in hand in Utah

DICHOTOMOUS KEY
FOR THE
BATS OF UTAH

Authored by: Chris Witt, Adam Kozlowski, and George Oliver
Figures by: Adam Kozlowski
Last edited: 23 August 2006

GBBC GREAT BASIN BAT COOPERATIVE

FIGURE | **STEP** | **DIAGNOSTIC**

Figure 1: Tail extends >5 mm beyond uropatagium.

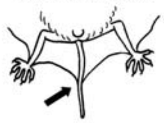


Figure 2: Tail does not extend more than 5 mm beyond uropatageum.

Figure 3: Small bumps present along leading edge of ears.

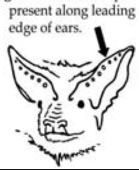


Figure 4: Ear length is measured from notch to tip.

Figure 5: Spotted bat's dorsal markings.

Figure 6: Lappets, flaps of skin, extending from base of each ear toward snout.

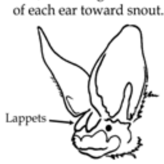


Figure 7: Muzzle with well defined dermal glands.

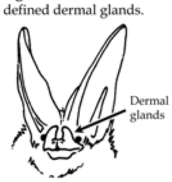


Figure 8: Tragus is short, blunt, rounded, and curved.

Figure 9: Tragus is long, pointed, and straight.

1 a. Tail extends beyond rear edge of uropatagium (interfemoral membrane) by more than 5 mm [Figure 1].
GO TO: 2 FAMILY: Molossidae

b. Tail does not extend beyond rear edge of uropatagium or only slightly (≤5 mm) [Figure 2].
GO TO: 3 FAMILY: Vespertilionidae

2 a. Ears do not join at the base, small bumps are present along the ear's front edge.
Ears barely extend past the shout when laid forward.
Tail generally does not extend >25 mm past interfemoral membrane; usually extends ~19 mm.
Fur is generally uni-colored, darkish gray/brown, species often exudes strong, musty odor.
BRAZILIAN FREE-TAILED BAT *(Tadarida brasiliensis)*

b. Ears join at the base, small bumps along the front edges of the ear are not present [Figure 3].
Ears extend well beyond the snout when laid forward.
Tail generally extends at least 25 mm past interfemoral membrane.
Fur is bi-colored, almost white at its base, distal color ranges from reddish-brown to black.
BIG FREE-TAILED BAT *(Nyctinomops macrotis)*

3 a. Ears longer than 25 mm [Figure 4].
GO TO: 4

b. Ears shorter than 25 mm.
GO TO: 7

4 a. Three conspicuous white spots present on back, one on each shoulder and one on lower back; [Figure 5].
Ears are pink.
SPOTTED BAT *(Euderma maculatum)*

b. Three dorsal spots not present.
GO TO: 5

5 a. Ears clearly separated at base; dorsal pelage is light brown to yellow, hairs lighter at base.
PALLID BAT *(Antrozous pallidus)*

b. Ears joined at base.
GO TO: 6

6 a. Each ear has lappet (flap of skin) near its base anteriorly, which extends forward toward snout [Figure 6].
Muzzle does not have well-defined dermal glands [Figure 7].
ALLEN'S BIG-EARED BAT *(Idionycteris phyllotis)*

b. Ears do not have basal lappets (flaps of skin) extending anteriorly.
Muzzle does have a well-defined pair dermal glands.
TOWNSEND'S BIG-EARED BAT *(Corynorhinus townsendii)*

7 a. Uropatagium (interfemoral membrane) heavily furred dorsally.
GO TO: 8

b. Uropatagium (interfemoral membrane) not heavily furred dorsally.
GO TO: 10

8 a. Weight is generally greater than 20 g; Light colored ears distinctly edged in black.
Dorsal pelage pale yellow/brown at base, black/dark brown in middle and white/cream at tip.
HOARY BAT *(Lasiurus cinereus)*

b. Weight is generally less than 20 g.
Dorsal pelage is not pale yellow/brown at base, black/dark brown in middle and white/cream at tip.
GO TO: 9

9 a. Fur color is dark brown to black with silver/white tips, giving a frosted appearance.
SILVERED-HAIRED BAT *(Lasionyceris noctivagans)*

b. Fur color is not dark brown to black with silver/white tips, rather it is brick red to rust on upperparts with pale undersides.
WESTERN RED BAT *(Lasiurus blossevillii)*

10 a. Tragus short (<6 mm), blunt, rounded, and curved [Figure 8].
GO TO: 11

b. Tragus long (>6 mm), pointed, and straight [Figure 9].
GO TO: 12

Figure 10: Uropatagium has conspicuous fringe of hairs on its posterior edge.

Figure 11: Underside of wing has long, dense fur extending outward from body.

Figure 12: Calcar keel not present or poorly developed.

Figure 13: Calcar keel is present and well developed.

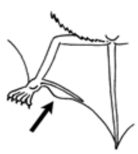


Figure 14: Naked part of snout top is as wide (w) as it is long (square).

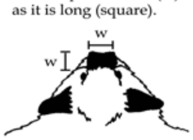
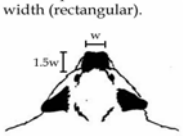


Figure 15: Naked part of snout top is 1.5X the nostril width (rectangular).



11 a. Forearm >40 mm (42 – 52); ears extend outward; mass greater than 11 g.
BIG BROWN BAT *(Eptesicus fuscus)*

b. Forearm <40 mm (28 – 33); mass less than 11 g.
WESTERN PIPISTRELLE *(Pipistrellus hesperus)*

12 a. Ears blackish and extend 4mm or more past end of snout when pressed forward.
LONG-EARED MYOTIS *(Myotis evotis)*

b. Ears extend less than 4 mm past end of snout when pressed forward.
GO TO: 13

13 a. Uropatagium (interfemoral membrane) has conspicuous fringe of hairs on its posterior edge; [Figure 10]. Fringe often accompanied by lighter skin pigmentation on uropatagium's trailing edge.
FRINGED MYOTIS ***(Myotis thysanodes)***

b. Uropatagium (interfemoral membrane) does not have conspicuous fringe of hairs (but may be very sparsely haired).
GO TO: 14

14 a. Underside of wing has long, dense fur extending outward from body to a line between elbow and knee [Figure 11].
LONG-LEGGED MYOTIS *(Myotis volans)*

b. Underside of wing does not have long, dense fur between elbow and knee.
GO TO: 15

15 a. Calcar keel is not well developed or is absent [Figure 12].
GO TO: 16

b. Calcar keel is present and well developed [Figure 13].
GO TO: 17

16 a. Fur of dorsal region is dull.
Forearm is generally less than 36 mm.
No keel on calcar.
Skull rises more abruptly from snout.
Ventral hairs black at base, light cream at tips.
YUMA MYOTIS *(Myotis yumanensis)*

b. Fur of dorsal region is glossy and long, longest dorsal hairs ~10 mm.
Forearm length 34 – 41mm.
May have poorly developed keel on calcar.
Snout to skull transition gradual.
Hairs on toes project beyond claws.
LITTLE BROWN MYOTIS *(Myotis lucifugus)*

17 a. Naked part of snout top is as wide as it is long (square) [Figure 14].
Tail does not extend beyond uropatagium.
Forehead rises steeply and abrubtly from rostrum.
Face, ears, and wings are not black and do not contrast sharply with pelage color.
CALIFORNIA MYOTIS *(Myotis californicus)*

b. Naked part of snout top is 1.5X the nostril width (rectangular) [Figure 15].
Tail often extends 1.5-2.5 mm beyond uropatagium.
Forehead rises gradually from rostrum.
Face, ears, and wings are black, often contrastingsharply with pale pelage.
WESTERN SMALL-FOOTED MYOTIS *(Myotis ciliolabrum)*

CHARACTERS USEFUL IN DISTINGUISHING UTAH'S SPECIES OF *MYOTIS*

Species	Body Mass (g)	Forearm (mm)	Ear (mm)	Keel on Calcar	Special Characteristics
californicus	3 – 6	29 – 36	9 – 15	Well developed	See step 17 to differentiate.
ciliolabrum	4 – 6	30 – 36	13 – 21	Well developed	See step 17 to differentiate.
yumanensis	4 – 7	32 – 36	12 –15	None	See step 16 to differentiate.
lucifugus	5 – 7	34 – 41	11 – 15	None	See step 16 to differentiate.
evotis	5 – 8	37 – 40	20 – 24	Poor	Ear length is distinctive among *Myotis*.
thysanodes	5 – 7	39 – 46	16 – 20	Poor to None	Short, dense hairs on trailing edge of tail.
volans	6 – 10	37 – 42	10 – 15	Well developed	Fur on wing between elbow and knee. Tibia is ≥2.5X the length of the hind foot.

Appendix 6. Field protocol for recording bat data

Bat Survey Data Form

1. Page ____ of ____

2. Date: ______________________ 3. Capture Location:____ 4. County/State: _______________________

5. Habitat/Site Description: ____ 6. Photographs: N ____ S_____ E ____ W _____

7. UTM Coordinates (Datum: NAD27): [| | | | | |] E [| | | | | | |] N, Zone (ex. 12T): [| |] 8. Elevation (m): _______________

9. Team Members: ____ 10. Recorder: ________________________

11. Methods Used (Mark all that apply): a) Mist Nets (Y/N)____ (surface area in m^2)___________ b) Harp Net (Y/N)____ c) Anabat (Y/N)____ d) Other _____________

e) Data logger (data type) __________________________ (interval in minutes) ______________________

12.	Start	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Total
13. Time (24 hr):												
14. Net Status:												
15. Detector Status:												
16. Logger Status:												
17. Temp (°C):												
18. Wind:												
19. Weather:												
20. Moon:												

21. Bat No.	22. Time (24 hr)	23. Temp (°C)	24. Species	25. FA (mm)	26. Ear (mm)	27. Tragus Shape	28. Keel (Y/N)	29. Sex (M/F)	30. Reproductive Status	31. Age (Ad/Juv)	32. Photo? (Y/N/#)	33. Mark? (Y/N)	34. Weight (g) *Tared*	35. Notes

ARE ALL THE FIELDS FILLED OUT COMPLETELY? PLEASE INITIAL:_____

Field Descriptions for Bat Survey Data Form

1. **Page__ of __:** Fill in the first blank with the current page number and the second blank with the total number of pages used during the survey period (ex. Page 2 of 3).
2. **Date:** The Day, Month, and 4 digit Year the survey was conducted (23 June 2005).
3. **Capture Location:** The ‘common’ name of the site being surveyed (ex. Nirvana Pond or Selman’s Ranch House).
4. **County/State:** The County and State in which the survey is being conducted (ex. Box Elder County, UT).
5. **Habitat/Site Description:** Short, simple description of surroundings and dominant vegetation within one mile of survey site. Description should also include the characteristics that caused the site to be selected (ex. presence of a stock pond, mine shaft, roost, etc.)
6. **Photographs:** Take one photograph in each cardinal direction (N,S,E,W) from the location the Coordinates were recorded (see #7). Note number of photograph if digital and applicable. Future photographs should always be taken from the same location to simplify historical comparisons.
7. **UTM Coordinates:** Record easterly (6 digit) and northerly (7 digit) UTM coordinates of the survey site using a GPS unit set to collect data in the North American Datum 1927 (NAD27).
8. **Elevation (m):** Use a GPS unit to record the Elevation at the same location the site’s Coordinates were taken (see #7). Record elevation in meters.
9. **Team Members:** Record the first and last names of the individuals conducting the survey. Record professional affiliations if applicable (ex. USFWS, USFS, TNC, etc.)
10. **Recorder:** Record the full name of the individual most often recording the data; insuring that questions about what was written can be directed to the right person.
11. **Methods Used:** Mark Yes (Y) for all the methods that were used during the current survey and No (N) for those not used. If mist nets are being used, calculate and record their surface area in square meters [surface area = height (m) x sum length of all nets open (m)]. If a data logger is being used, note the type of data it is collecting (ex. temperature, humidity, barometric pressure) and the intervals to which it is set to collect data (ex. 5 min.). Use the Other category to record other methods employed during the survey period.
12. **Start; Hour 1…:** The status of Fields 13-20 should be recorded at the Start of the survey period and each consecutive 60 minutes after until the end of the survey. Uneven starting or ending times of either the nets, data loggers, or ultrasonic detectors should be recorded in the Hour column closest to the event. The actual time for each event will be recorded in Field 13.
13. **Time:** Actual time that the statuses of Fields 14 thru 20 are recorded.
14. **Net Status:** Record whether nets are ‘Open’ or ‘Closed’ at time in Field 13.
15. **Detector Status:** Recorded whether an ultrasonic detector is ‘Active’ or ‘Not Active’ at time in Field 13.
16. **Logger Status:** Recorded whether a data logger is ‘Active’ or ‘Not Active’ at time in Field 13.
17. **Temp (°C):** Record the temperature in degrees Celsius at time in Field 13.
18. **Wind:** Use MPH categories as determined from the Beaufort Wind Scale. 1) *0-1 MPH*: Calm; smoke rises vertically. 2) *1-3* MPH: Direction of wind shown by smoke drift, but not by wind vanes. 3) *4-7* MPH: Wind felt on face, leaves rustle, ordinary vane moved by wind. 4) *8-12* MPH: Leaves and small twigs in constant, gentle motion; wind extends light flag. 5) *13-18* MPH: Raises dust and loose paper; small branches are moved. In most situations winds in categories 3, 4, and 5 will not be conducive to operating mist nets.
19. **Weather:** Record the dominant weather over the last hour: 1*) Clear*: 0-10% cloud cover. 2) *Partly*: 10%-50% cloud cover. 3) Cloudy: 50%-100% cloud cover. 4) *Precip:* some amount of precipitation fell during this hour.
20. **Moon:** Record phase of moon as: 1) *None*: Either a new moon, just risen, or just set. 2) *Crescent*: 0-25% lit. 3) *Half:* 25-75% lit. 4) *Full*: 75-100% lit. 5) *Obscured*: Obscured by cloud cover.
21. **Bat No.:** Number the bats as they are caught (ex. 1, 2,3 …).
22. **Time (24 hr):** The time the bat *was caught*, not the time it was processed (ex. 2234).
23. **Temp (°C):** The temperature in degrees Celsius when the bat *was caught*, not when it was being processed.
24. **Species:** Use a dichotomous bat key for the area the survey is being conducted to help identify bats to species. It is likely that characters in addition to the Fields below will be needed for proper identification.
25. **FA (mm):** The length of the forearm in millimeters. The forearm is defined as the length between the elbow and the distal side of the wrist (Figure 1).
26. **Ear (mm):** The length of the ear in millimeters. The ear length is measured from the notch on the base of the ear to the ear’s tip (Figure 2).
27. **Tragus Shape:** Note the shape of the tragus as either 1) Long and Pointed (Figure 3a) or 2) Short and Rounded (Figure 3b). Especially useful to determine identification of Pipestrelles.
28. **Keel:** Note the 1) Presence or 2) Absence of a flap of skin hanging loose off the posterior edge of the calcar (Figure 4a & b).
29. **Sex:** Record the sex of the bat as 1) Male or 2) Female. Evidence of sex is best obtained from the genitalia, with the males possessing a well developed penis.
30. **Reproductive Status:** Record the reproductive status of the Males as either 1) Reproductive – one or both testes have descended or 2) Non-reproductive – neither testes are descended. For the Female note evidence of 1) Lactating – nipples are pink and enlarged, hair surrounding the nipple is worn. 2) Post-lactating – nipples wrinkly and dark hair has often grown back. 3) Pregnant – presence of unborn fetus evident. 4) Non-reproductive – nipples very small and well haired.
31. **Age:** Record the age of the bat as either 1) Juvenile or 2) Adult based on the calcification of the phalangeal joints. Best observed by shining the joints from behind with a head lamp (Figure 5).
32. **Photo?:** Record whether a photograph was taken of the bat with a Yes (Y) or (N). Note number of photograph if digital and applicable.
33. **Mark?:** Record whether the animal was marked before release with a Yes (Y) or No (N). Note method of marking in the Notes (ex. Marker, band, tattoo, freeze brand, etc.)
34. **Weight:** The total weight of the bat minus the weight of the bag in grams.
35. **Notes:** To be used to record observations or actions of this particular bat not accounted for by the data sheet (ex. parasite load, marking method, injuries, capture method, etc.)

Figure 1:
Forearm =elbow to wrist

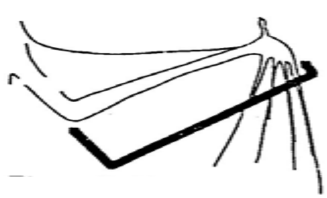


Figure 2:
Ear = notch bottom to tip

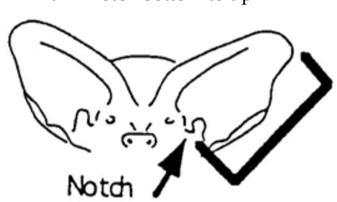


Figure 3: Tragus shape
a) long, pointed b) short, rounded

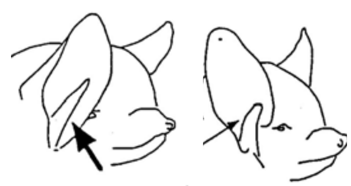


Figure 4: Keeled calcar
a) Present b) Absent

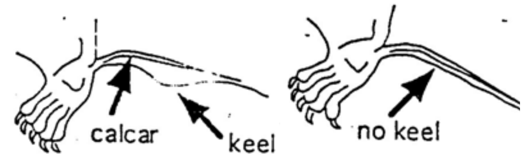
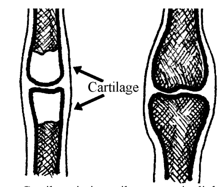


Figure 5: Age
a) Juvenile b) Adult



Cartilage in juveniles transmits light; appears whitish when backlit.

Appendix 7. Field key for acoustic identification of Utah bats

DRAFT

Anabat® Call Key
for the Utah Bat Conservation Cooperative

Developed by
Diane Probasco
Ashley National Forest
Vernal, Utah

DISCLAIMER

***This is not a definitive classification key*.**

Anabat® is a system designed to help users find and identify echolocating bats by digitally recording those calls and plotting them on a computer screen (please see the following web site for more information: http://users.lmi.net/corben/anabat.htm#Anabat%20Contents). These echolocation calls are notoriously hard to distinguish at the species level, due to the wide variation in recording quality, intra-species call morphology, and environmentally induced frequency shifts. Correct analysis depends heavily on the accumulated experience of the analyst.

Some bats (e.g., hoary bats, spotted bats) can readily be identified by new users, but other species (e.g., myotis volans and myotis ciliolabrum) are very difficult to distinguish, even by experts. This key is meant to provide a starting point for biologists wishing to analyze bat calls recorded in Utah. Even with this information, many calls cannot be identified at the species level rather most species can be identified to the appropriate glade.

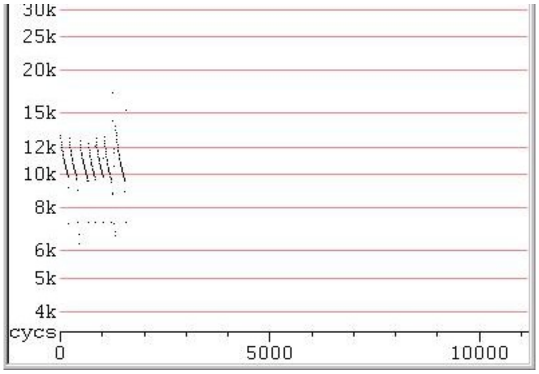
Before employing this key, users should be familiar with the general principles of call analysis (e.g., see http://users.lmi.net/corben/glossary.htm #Glossary). With such background information, this key can be used to roughly classify calls and perhaps (given well-recorded calls) identify the particular species making those calls. Questionable calls, calls of difficult to distinguish species, or those that represent new occurrences in an area should always be viewed by local Anabat® experts. Analyzing bat calls can be very challenging and frustrating, but with patience and experience it provides a fascinating look at our bat communities. Please let me know if you found this document useful or if you have suggestions for improving it.

Thank you,
Diane Probasco

Anabat® Call Key

- Fmin (kHz)
  - <10
    - EUMA
  - 16- 20
    - 20 k Bats (LACI, IDPH, NYMA, NYFE, EUPE)
  - ~25
    - 25 k Bats (EPFU or LANO)
  - 25-35
    - 30 k Bats (MYTH, MYEV, COTO, ANPA, TABR)
  - 40
    - 40 k Bats (MYLU, MYVO, MACI)
  - 40-50
    - 50 k Bats (PIHE, MYYU, MYCA, LABL)

10 k Bat
EUPE *Euderma perotis*
Calls steep and sparse; usually beginning above 10kHz and ending below 8kHz.



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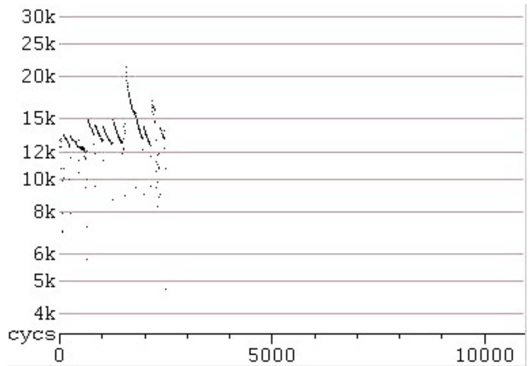
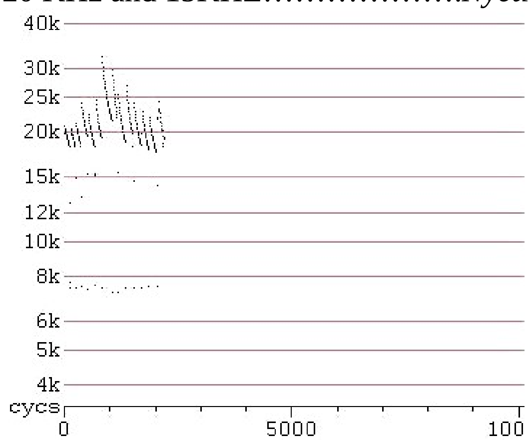
20 k Bats (LACI, IDPH, NYMA, NYFE, and EUPE)

1. Call curved…………………………………………………………………………2
1a. Call nearly vertical, may have a slight slant…………………………………..3

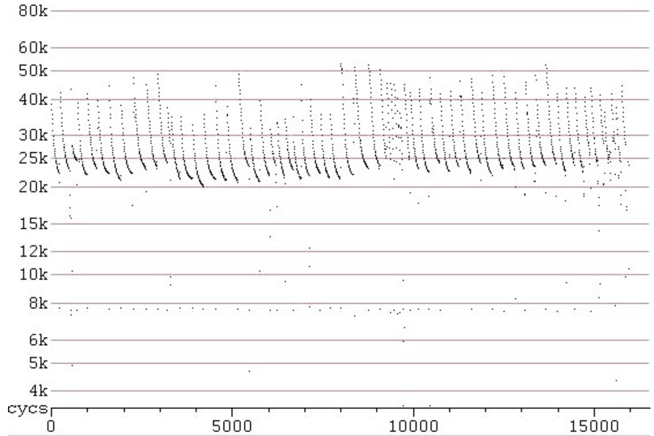
2. Call curved, usually with a strong knee; audible to human ear; call starts between 10KHz and 16KHz……………………………………….…*Nyctinomops macrotis*



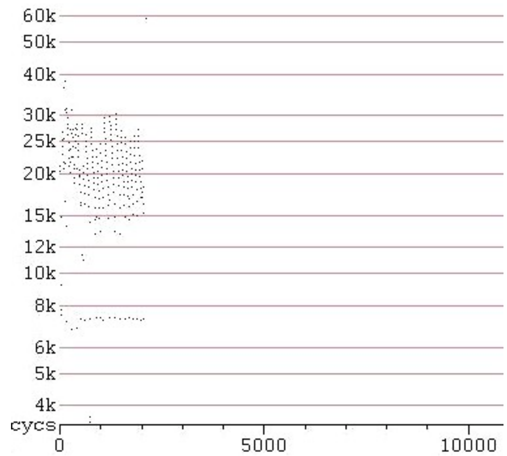
2a. Call start between 20 KHz and 15KHZ………………*Nyctinomops femorosaccus*



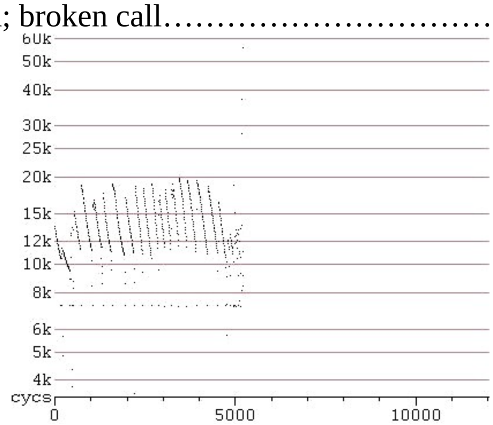
3. Call nearly vertical, slightly slanted or slightly curved...…………………………4
3a. Calls usually low slope and can be hook-shaped; characterized by long duration FM (F_{min} = 20-24; F_{max} = 41-50 KHz); calls interspersed with CF (F_{min} = 18 F_{max} = 25) this **phase shift** is diagnostic; often give several calls at a higher freq, but with same shape………………………………………………………*Lasiurus cinereus*



4. Call nearly vertical, somewhat slanted with little curve; very quiet; usually starts at 14KHz. May also show a louder feeding or social buzz that starts as high as 25KHz to 30KHz. Rare harmonics……………………….…*Idionycteris phylottis*

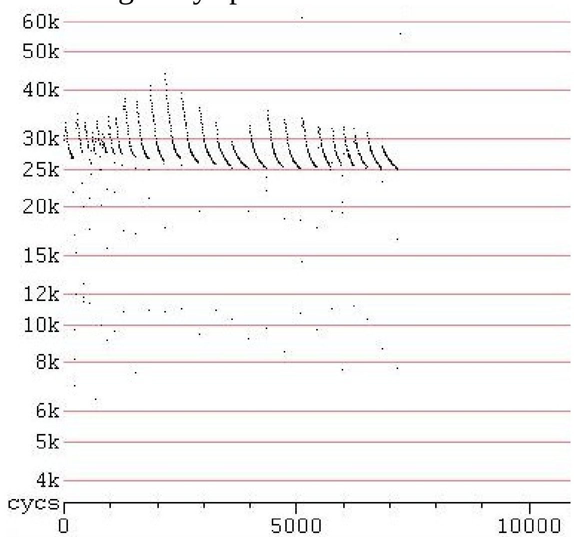


4a. Call slightly slanted; broken call……………………………..…….*Eumops perotis*

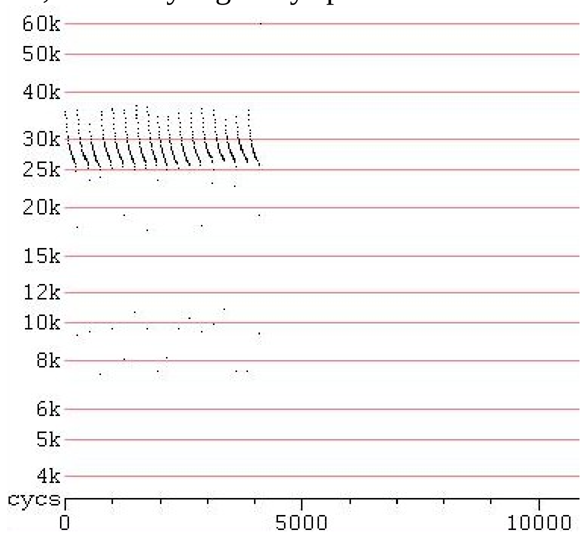


25 k Bats (LANO and EPFU)

1. Slope of tail is very consistent; usually very curved, but can be more bilinear when they are short in sweep (i.e., ~25-40), occasionally nearly flat; starting frequency (~30 KHz) of syllables is consistent; F_{max} = 45-52 KHz; Fmin often not uniform, with some calls falling below 25k; no syllables with knee or droop and end. Calls sometimes irregularly spaced……………………..*Eptesicus fuscus*



1a. Syllables with no knee or droop; little or no harmonics, calls range from nearly vertical with curve only at end to nearly flat; sweeps begin as broken and steeply modulated calls (F_{max} ~45 KHz), but become more CF toward terminal and longer portion (F_{min} = 26-30 KHz); slope plots usually "dribble off" rather than forming "fishhook" ends; calls are more bilinear than EPFU. Slope of tail is more variable than EPFU; calls very regularly spaced………*Lasionycteris noctivagans*



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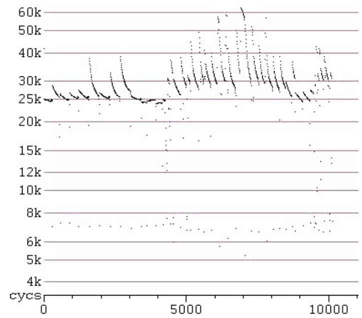
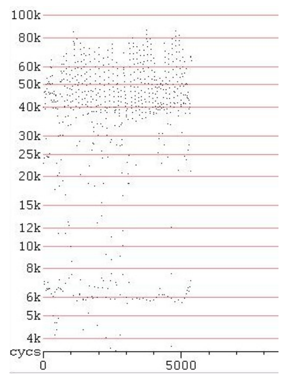
30 k Bats (MYTH, MYEV, COTO, ANPA, and TABR)

1. Calls broken; Steep slope calls…………………………………………………2
1a. Call with strong tail “reverse J shape” with CF or vertical with knee and droop; F_{min} = 23-28 KHz; some part of call (usually the end) consists of nearly flat syllables; may have very unusual syllables that look like snakes or “Z” ‘s; MANY variations…………………………………………………...…*Tadarida brasiliensis*

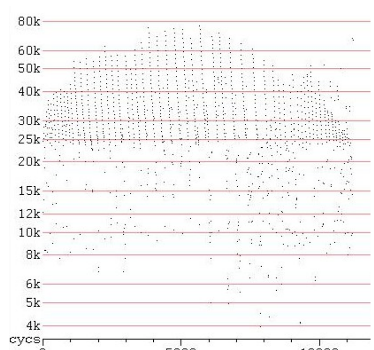


2. Call shows no tail…………………………………………………………………3
2a. Call shows very little tail or tail getting thinner at end……………………………4

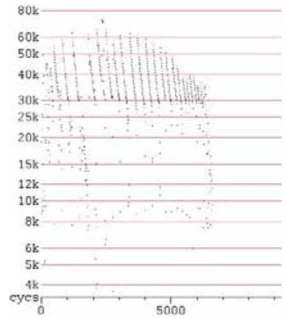
3. Call very sparse, with no tail; call seldom dropping below 30; Call is very quiet; vertical or slightly slanted; straight; usually starts near 35KHz, usually reaches 80KHz at the top; F_{min} ~35 KHz; F_{max} = 70-80 KHz (highly broken)……………………………………………………………..…*Myotis evotis*



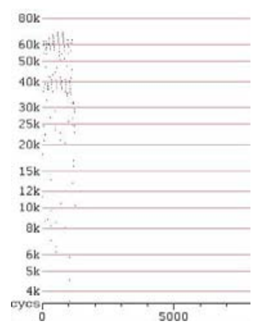
3a. Call Variable Fmin with some calls usu. dropping to or below 25. Freq range usually $\geq$50; F_{min} ~25-27 KHz; F_{max} = 70-75 KHz (steep, highly broken throughout); Call quiet; mostly straight, with little curve; no tail ……………………………………………………………..……*Myotis thysanodes*



4. Calls steep, but often slightly more curved than MYTH or MYEV and somewhat “thicker”; F_{min} = 30-35 KHz; = 60-70 KHz; Very little tail, but sometime “dribbling off” in a “lazy S” shape; Can also be difficult to tell from EPFU in clutter, which will usually have time between calls of <100ms ……….……………………………………………………………..*Antrozus pallidas*



4a. Calls steep, weak, have two harmonics; strong similarity to ANPA but even more broken and starting frequency (F_{max}) perhaps slightly lower;. Fmin usually ~30, but can be 25. Harmonic-break often between 40-50; sometimes only one harmonic captured; upper can look like 50k myotis; lower can look like steep 25k getting thinner at tail……………………………………..*Corynorhinus townsendii*



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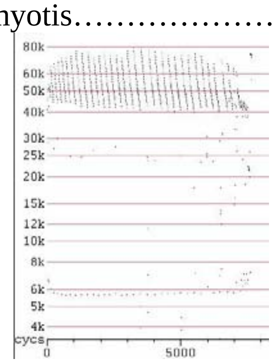
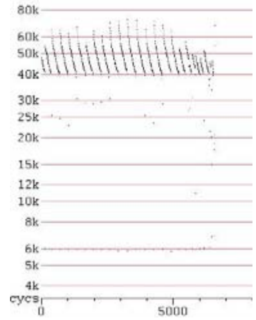
40 k Bats (MYLU, MYVO and MYCI)

1. Call vertical with knee and droop; harmonics; calls steep often with “wiggly look”; No part of the call goes below 41KHz, moderately quiet, slight curve; F_{min} = 39-42 KHz; F_{max} = 60-65 KHz; like MYLU in clutter, but greater call spacing; calls tend to be more linear (or bilinear) than MYLU and have less “toe” than MYCI; calls can have a wobble high in the sweep (usually _50k); difficult to distinguish from other 40k myotis………………………………….…..*Myotis volans*

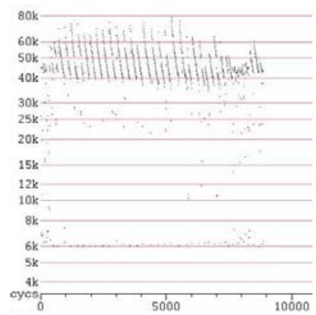


1a. Call gently curved slope…………………………………………………………...2

2. Gently curved slope throughout call (but often get more bilinear in clutter and may "dribble off" at the end); usually starts right at 40KHz; there is usually some knee; F_{min} ~35-40 KHz; F_{max} = 70 KHz; sometimes alternate curved call with a more linear one. *Behavior*: MYLU classically feed over water, which can result in "wobbly" calls."………..…………………………………………*Myotis lucifugus*



2a. Call is straight or slightly curved; calls steep and regularly have a small "toe" at or just before the end, resulting in a "golfclub" or "S" shaped call; F_{min} = 40-43 KHz; F_{max} = 80+; clean calls usually straighter than MYLU, but can be more curvilinear than MYVO. Calls can have a wobble in the middle of the call (usually _50k). *Behavior*: MYCI feed around vegetation, like MYCA ……………………………………………………………….....*Myotis ciliolabrum*



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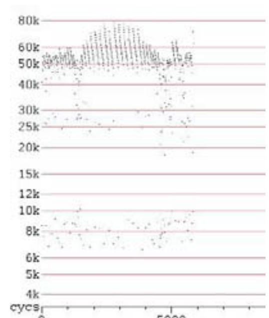
50 k Bats (PIHE, MYYU, MYCA and LABL)

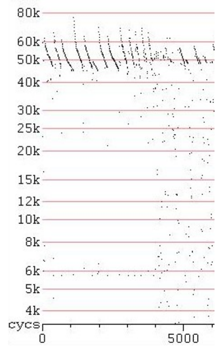
1. Call is nearly straight or with a slight (vertical) consistent curve and goes up to 80-100 KHz; no part of the call goes below 45KHz, the; Calls frequently have a flat "toe" at the end, rather than dribbling off. Toed calls usually have Min. slope of 30ish. "Dribbling calls" usually have Min. slope greater than MYYU (i.e., above 40). *Behavior*: MYCA typically feed by hugging vegetation………………. ……………………………………………………………….*Myotis californicus*



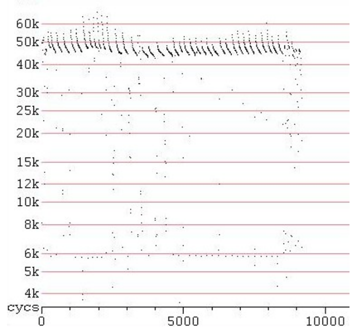
1a. Calls not straight (vertical)………………………………………………………2

2. Calls are very curved (reverse J) strong and dense………………………………3

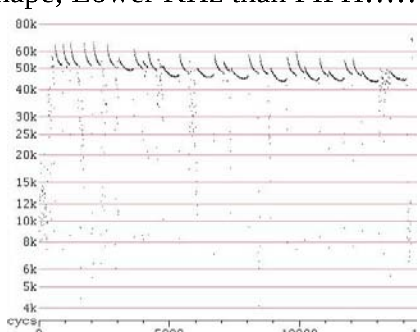
2a. Call gently curved; often show calls dropping below 50k (~45k); call shape similar to MYLU, but thicker tail; calls often "dribbleoff", rather than having constant toes; dribble calls can have slope down to 40; in a series, there is often one call that is flatter than the rest. *Behavior*: MYYU often feed over water…………………………………………………………*Myotis yumanensis*



3. Call is very curved (reverse "J"-shape), strong and dense; F_{min} = 47-50 KHz; F_{max} = 55-80 KHz (entire call may be below 50 KHz); thick calls with flat tails often with a drooping tail…………………………………………..*Pipistrellus hesperus*



3a. Call has a strong "J"-shape; Lower KHz than PIPH……...…...*Lasiurus blossevilli*



Appendix 8. Predictive Utah bat habitat model

1. Diagram of Predicitive Bat Habitat Model Algorithms. Adapted from Keinath 2004.

Step 1: Score individual theme features (Type, Distance, and Modifier components). → **Step 2:** Apply weighting factors and structure modifiers. → **Step 3:** Combine each theme value via modeling formula to create final habitat suitability score.

General Type Score (tsi)

Used in Models: WET, VEG, GEO

tsi	Description
0	Avoided or Never Used
1	Possible Use
2	Used as Available
3	Preferred Habitat

General Distance Score (dsi)

Used in Models: WET, GEO, CLF

dsi	Description
0	> 20 km
1	10-20 km
2	1-10 km
3	< 1km

Nearest Type Score ($tsi^{nearest}$)

Used in Models: WET, GEO

Score from 0 to 3 to match value of nearest suitable neighbor and assigned spatially by GIS.

Model Weights (w^c and w^{te})

Used in Models: WET, GEO

Used to weight intra-model components.

Elevation Score (tsi)

Used in Models: ELV

tsi	Description
0	≥11,000 ft (3353 m); ice in caves, no insects
1	9,001-11,000 ft (2744 - 3353 m)
2	3,501-9,000 ft (1067 - 2743 m)
3	≤3,500 ft (1067 m)

Aspect Score (tsi)

Used in Models: ASP

tsi	Description
0	North (315-360°; 0-45°)
1	WNW (270-315°)
2	WSW (225-270°)
3	South-Southeast-East (45-225°)

Cliff Modifier Score (smi)

Used in Models: CLF

smi	Description
0	not a cliff (0-59° slope)
1	cliff (60-90° slope)

Geology/Water Modifier Score (smi)

Used in Models: GEO/WET

smi	Description
0	Bedrock below surface/Not water
1	Bedrock at surface/Water

Model Weight (w^m)

No.	Description	w^m
1	not applicable	0
2	↓	0.5
3		1
4		1.5
5	very important	2

<u>Water Source Model</u>

$$WET = w^m * smi^{WET} * [w^c(tsi^{WET}) + w^c(dsi^{WET}) + w^{te}(tsi^{nearest}-3)]$$

<u>Landcover Model</u>

$$VEG = w^m * [w^c(tsi^{VEG-ROOST}) + w^c(tsi^{VEG-FORAGE})]$$

<u>Geology Model</u>

$$GEO = w^m * smi^{GEO} * [w^c(tsi^{GEO}) + w^c(dsi^{GEO}) + w^{te}(tsi^{nearest}-3)]$$

<u>Elevation Model</u>

$$ELV = w^m * (tsi^{ELV})$$

<u>Slope Model</u>

$$CLF = w^m * (smi^{CLF} * dsi^{CLF})$$

<u>Aspect Model</u>

$$ASP = w^m * (tsi^{ASP})$$

<u>FINAL SUITABILITY MODEL</u>

FINAL = WET + VEG + GEO + ELV + CLF + ASP

Model Scores and Weights by Theme

Theme	Code	Model Weight (w^m)	Type Score & Weight (tsi/w^c)	Distance Score & Weight (dsi/w^c)	Type Effect Weight (w^{te})
Water Sources	WET	2	0.1*(0-3)	0.9*(0-3)	0.7
Landcover (habitat)	VEG	1.5	0.5*(0-3)+ 0.5*(0-3)		–
Geology (caves, crevices)	GEO	1.5	0.1(0-3)	0.9(0-3)	0.7
Elevation (temp)	ELV	1	0-3	–	–
Slope (cliffs)	CLF	1	–	0-3	0.7
Aspect (thermal heating)	ASP	1	0-3	–	–

Predictive Bat Habitat Model - Water Sources Score Sheet

2a **Water Source Weighted Cell Model:** $WET = w^m * smi^{WET} * [w^c(tsi^{WET}) + w^c(dsi^{WET}) + w^{te}(tsi^{nearest}-3)]$

2b **Water Sources Type Score (tsi^{WET}):** Suitability of each water source class for use by bats (foraging and drinking).

No.	Description	Type Score (tsi^{WET})
1	Flat Water, Small (<.01 acres), Intermittent	2
2	Flat Water, Small (<.01 acres)	3
3	Flat Water, Medium (.01-100 acres)	3
4	Flat Water, Large (>100 acres)	3
5	Flat Water, Marsh/Wetland	3
6	Flat Water, Sour, GSL, Playa	1
7	Stream (<10m)- Intermittent	2
8	Stream (<10m)- Perennial	3
9	River (>10m) - Inundation/Intermittent	2
10	River (>10m) - Perennial	3

Type Score (tsi^{WET})

Description	Type Score (tsi)
Avoided or never used	0
Possible use	1
Used as available	2
Preferred habitat	3

2c **Water Sources Distance Score (dsi^{WET}):** Value of a grid cell relative to its proximity to water.

No.	Description	Distance Score (dsi^{WET})
1	> 20 km	0
2	10-20 km	1
3	1-10 km	2
4	< 1km	3

Distance Score (dsi^{WET})

Description	Dist. Score (dsi)
Avoided or never used	0
Possible use	1
Used as available	2
Preferred habitat	3

2d **Component Weight (w^c):** Each model component (tsi & dsi) must be assigned a weight relative to each other, see detailed analysis in Appendix A.

No.	Description	Component Weight (w^c)
1	Weight of **tsi^{WET}**	0.1
2	Weight of **dsi^{WET}**	0.9

2e **Type Effect [$w^{te}(tsi^{nearest}-3)$]:** This portion of the WET algorithm is designed specifically to incorporate the effect of the nearest water type on cells that are not classified as water (tsi=0). Although such cells' immediate tsi scores = 0, these cells must maintain some 'knowledge' of the value of the water cell to which they are most closely associated to be ranked properly. The Nearest Type Score ($tsi^{nearest}$) is the score of the nearest water cell (0-3) within 20 km (greater than 20 km and dsi =0 and tsi=0) and is determined spatially. The Type Effect Weight (w^{te}) is used to moderate the extent of the Type Effect has and is analyzed in more detail in Appendix A tab.

No.	Description	Value
1	Type Effect Weight (w^{te})	0.7

Predicitive Bat Habitat Model - Landcover Score Sheet

3a	Land Cover Weighted Cell Model:	$VEG = w^m * [w^c(tsi^{VEG-ROOST}) + w^c(tsi^{VEG-FORAGE})]$

3b **Landcover Type Score (tsi^{VEG}):** Suitability of each vegetation community type for use by bats (foraging, roosting).

No.	SWReGAP Code	SWReGAP Legend Page	SWReGAP Land Cover Classes	Type Score ($tsi^{VEG-ROOST}$)	Type Score ($tsi^{VEG-FORAGE}$)
ALTERED OR DISTURBED					
1	D01	5	**Disturbed, Non-specific**	0	0
2	D02	6	**Recently Burned**		
3	D03	6	**Recently Mined or Quarried**	2	1
4	D04	6	**Invasive Southwest Riparian Woodland and Shrubland**	2	2
5	D06	6	**Invasive Perennial Grassland**	0	1
6	D08	6	**Invasive Annual Grassland**	0	1
7	D09	6	**Invasive Annual and Biennial Forbland**	0	1
8	D10	6	**Recently Logged Areas**		
9	D11	6	**Recently Chained Pinyon-Juniper Areas**	2	3
10	D14	6	**Disturbed, Oil well**	1	1
OTHER COVER TYPES					
11	N31	5	**Barren Lands**, Non-specific	0	1
DEVELOPED AND AGRICULTURE					
12	N21	5	**Developed**, Open Space - **Low Intensity**	3	2
13	N22	5	**Developed, Medium - High Intensity**	2	2
14	N80	5	**Agriculture**	2	2
BARREN LAND TYPES					
15	S001	7	North American **Alpine Ice Field**	0	0
16	S004	9	Rocky Mountain **Alpine Fell-Field**	1	1
17	S012	16	Inter-Mountain Basins **Active and Stabilized Dune**	0	3
18	S014	19	Inter-Mountain Basins **Wash**	0	1
19	S015	20	Inter-Mountain Basins **Playa**	0	0
20	S020	25	North American Warm Desert **Wash**	1	3
21	S022	28	North American Warm Desert **Playa**	0	0
DECIDUOUS FOREST					
22	S023	29	Rocky Mountain Aspen **Forest and Woodland**	3	3
23	S024	29	Rocky Mountain **Bigtooth Maple Ravine Woodland**	2	2
EVERGREEN FOREST					
24	S025	33	Rocky Mountain **Subalpine-Montane Limber-Bristlecone Pine Woodland**	2	2
25	S026	34	Inter-Mountain Basins **Subalpine Limber-Bristlecone Pine Woodland**	2	2
26	S028	35	Rocky Mountain Subalpine Dry-Mesic **Spruce-Fir Forest and Woodland**	3	3
27	S030	38	Rocky Mountain Subalpine Mesic **Spruce-Fir Forest and Woodland**	3	3
28	S031	39	Rocky Mountain **Lodgepole Pine Forest**	3	3
29	S032	41	Rocky Mountain Montane Dry-Mesic **Mixed Conifer Forest and Woodland**	3	3

30	S034	45	Rocky Mountain Montane Mesic **Mixed Conifer Forest and Woodland**	3	3
31	S036	48	Rocky Mountain **Ponderosa Pine Woodland**	3	3
32	S039	52	Colorado Plateau **Pinyon-Juniper Woodland**	3	3
33	S040	54	Great Basin **Pinyon-Juniper Woodland**	3	3
MIXED FOREST TYPES					
34	S042	65	Inter-Mountain West **Aspen-Mixed Conifer Forest** and Woodland Complex	3	3
SHRUB/SCRUB TYPES					
35	S043	67	Rocky Mountain **Alpine Dwarf-Shrubland**	0	1
36	S045	69	Inter-Mountain Basins Mat **Saltbush Shrubland**	0	2
37	S046	70	Rocky Mountain **Gambel Oak-Mixed Montane Shrubland**	1	2
38	S047	72	Rocky Mountain **Lower Montane-Foothill Shrubland**	2	2
39	S050	74	Inter-Mountain Basins **Mountain Mahogany Woodland and Shrubland**	2	2
40	S052	75	Colorado Plateau **Pinyon-Juniper Shrubland**	2	2
41	S053	76	Great Basin **Semi-Desert Chaparral**	1	2
42	S054	77	Inter-Mountain Basins **Big Sagebrush Shrubland**	1	2
43	S055	79	Great Basin **Xeric Mixed Sagebrush Shrubland**	0	2
44	S056	80	Colorado Plateau **Mixed Low Sagebrush Shrubland**	0	2
45	S057	81	Mogollon **Chaparral**	1	3
46	S059	83	Colorado Plateau **Blackbrush-Mormon-tea Shrubland**	0	2
47	S060	85	Mojave **Mid-Elevation Mixed Desert Scrub**	2	2
48	S065	91	Inter-Mountain Basins **Mixed Salt Desert Scrub**	0	1
49	S069	95	Sonora-Mojave **Creosotebush-White Bursage Desert Scrub**	0	2
50	S070	97	Sonora-Mojave **Mixed Salt Desert Scrub**	0	1
51	S114	98	Sonora-Mojave-Baja **Semi-Desert Chaparral**	1	2
52	S128	100	Wyoming Basins **Low Sagebrush Shrubland**	0	1
53	S136	102	Southern Colorado Plateau **Sand Shrubland**	0	1
GRASSLAND/HERBACEOUS TYPES					
54	S071	104	Inter-Mountain Basins **Montane Sagebrush Steppe**	0	3
55	S075	107	Inter-Mountain Basins **Juniper Savanna**	2	2
56	S078	110	Inter-Mountain Basins **Big Sagebrush Steppe**	1	2
57	S079	111	Inter-Mountain Basins **Semi-Desert Shrub Steppe**	0	2
58	S081	114	Rocky Mountain **Dry Tundra**	0	0
59	S083	116	Rocky Mountain **Subalpine Mesic Meadow**	1	3
60	S085	117	Southern Rocky Mountain **Montane-Subalpine Grassland**	0	2
61	S090	126	Inter-Mountain Basins **Semi-Desert Grassland**	0	1
WOODY WETLAND TYPES					
62	S091	133	Rocky Mountain **Subalpine-Montane Riparian Shrubland**	2	3
63	S092	136	Rocky Mountain **Subalpine-Montane Riparian Woodland**	3	3
64	S093	137	Rocky Mountain **Lower Montane Riparian Woodland and Shrubland**	3	3
65	S094	140	North American Warm Desert **Lower Montane Riparian Woodland and Shrubland**	3	3
66	S096	145	Inter-Mountain Basins **Greasewood Flat**	1	2
67	S097	146	North American Warm Desert **Riparian Woodland and Shrubland**	3	3
68	S098	148	North American Warm Desert **Riparian Mesquite Bosque**	3	3

69	S118	149	Great Basin **Foothill and Lower Montane Riparian Woodland and Shrubland**	3	3
EMERGENT HERBACEOUS WETLAND TYPES					
70	S100	154	North American Arid West **Emergent Marsh**	0	3
71	S102	156	Rocky Mountain **Alpine-Montane Wet Meadow**	0	3

3c **Component Weight (w^c):** Each model component (tsi^{ROOST} & tsi^{FORAGE}) must be assigned a weight relative to each other.

No.	Description	Component Weight (w^c)
1	Weight of $\mathbf{tsi}^{VEG\text{-}ROOST}$	0.5
2	Weight of $\mathbf{tsi}^{VEG\text{-}FORAGE}$	0.5

Predictive Bat Habitat Model - Geology Score Sheet

4a | **Geology Weighted Cell Model:**

$$GEO = w^{m} * smi^{GEO} * [w^{c}(tsi^{GEO}) + w^{c}(dsi^{GEO})] + w^{te}(tsi^{nearest}-3)]$$

4b **Geology Structure Modifier (smi^{GEO}):** Binary filter selecting for exposed rock formations.

No.	Description	Structure Modifier Score (smi^{GEO})
1	Bedrock below surface	0
2	Bedrock at surface	1

4c **Geology Type Score (tsi^{GEO}):** Suitability of each exposed bedrock cover class for use by bats.

No.	SWReGAP Code	SWReGAP Legend Page	SWReGAP Land Cover Classes	Type Score (tsi^{GEO})
1	S002	7	Rocky Mountain **Alpine Bedrock and Scree**	0
2	S006	10	Rocky Mountain **Cliff and Canyon**	3
3	S009	13	Inter-Mountain Basins **Cliff and Canyon**	3
4	S010	13	Colorado Plateau **Mixed Bedrock Canyon and Tableland**	3
5	S011	15	Inter-Mountain Basins **Shale Badland**	1
6	S013	17	Inter-Mountain Basins **Volcanic Rock and Cinder Land**	3
7	S016	21	North American Warm Desert **Bedrock Cliff and Outcrop**	3
8	S019	24	North American Warm Desert **Volcanic Rockland**	3

Type Score (tsi^{GEO})

Description	Type Score (tsi)
Avoided or never used	0
Possible use	1
Used as available	2
Preferred habitat	3

4d **Geology Distance Score (dsi^{GEO}):** Value of this grid cell relative to its proximity to geologic roosting cover (cracks, crevices, caves, etc.).

No.	Description	Distance Score (dsi^{GEO})
1	>20 km	0
2	11-20 km	1
3	1-10 km	2
4	<1 km	3

Distance Score (dsi^{GEO})

Description	Dist. Score (dsi)
Avoided or never used	0
Possible use	1
Used as available	2
Preferred habitat	3

4e **Component Weight (w^{c}):** Each model component (tsi^{GEO} & dsi^{GEO}) must be assigned a weight relative to each other.

No.	Description	Component Weight (w^{c})
1	Weight of $\mathbf{tsi}^{GEO}$	0.1
2	Weight of $\mathbf{dsi}^{GEO}$	0.9

4f **Type Effect [$w^{te}(tsi^{nearest}-3)$]:** This portion of the GEO algorithm is designed specifically to incorporate the effect of the nearest exposed bedrock on cells that are not classified as exposed bedrock (tsi=0). Although such cells' immediate tsi scores = 0, these cells must maintain some 'knowledge' of the value of the geology type to which they are most closely associated to be ranked properly. The Nearest Type Score ($tsi^{nearest}$) is the score of the nearest cell demonstrating the presence of a exposed geology cover class (0-3) within 20 km (greater than 20 km and dsi =0 and tsi=0) and is determined spatially. The Type Effect Weight (w^{te}) is used to moderate the extent of the Type Effect has and is analyzed in more detail in Appendix A tab.

No.	Description	Value
1	Type Effect Weight (w^{te})	0.7

Predicitive Bat Habitat Model - Elevation Score Sheet

5a	Elevation (temperature) Weighted Cell Model:	$ELV = w^m * (tsi^{ELV})$

5b **Elevation Type Score (tsi^{ELV}):** Suitability of elevation bands (temperature zones) for use by bats.

No.	Description	Type Score (tsi^{ELV})
1	≥11,000 ft (3353 m); ice in caves, no insects	0
2	9,001-11,000 ft	1
3	3,501-9,000 ft	2
4	≤3,500 ft (1067 m)	3

Type Score (tsi^{ELV})

Description	Type Score (tsi)
Avoided or never used	0
Possible use	1
Used as available	2
Preferred habitat	3

Predicitive Bat Habitat Model - Slope Score Sheet

6a	Slope (cliff) Weighted Cell Model:	$CLF = w^m * (smi^{CLF} * dsi^{CLF})$

6b **Slope Structure Modifier (smi^{CLF}):** Binary filter selecting for steep slopes.

No.	Description	Structure Modifier Score (smi^{CLF})
1	not a cliff (0-59° slope)	0
2	cliff (60-90° slope)	1

6c **Slope (cliff) Distance Score (dsi^{CLF}):** Value of a grid cell relative to its proximity to cliffs.

No.	Description	Distance Score (dsi^{CLF})
1	>20 km	0
2	11-20 km	1
3	1-10 km	2
4	<1 km	3

Distance Score (dsi^{CLF})

Description	Dist. Score (dsi)
Avoided or never used	0
Possible use	1
Used as available	2
Preferred habitat	3

Predicitive Bat Habitat Model - Aspect Score Sheet

7a	**Aspect Weighted Cell Model:**	**$ASP = w^{m} * (tsi^{ASP})$**

7b **Aspect Type Score (tsi^{ASP}):** value of a cell's suitability for bats relative to aspect (thermal heating).

No.	Description	Type Score (tsi^{ASP})
1	North (315-360°; 0-45°)	0
2	WNW (270-315°)	1
3	WSW (225-270°)	2
4	South-Southeast-East (45-225°)	3

Type Score (tsi^{ASP})

Description	Type Score (tsi)
Avoided or never used	0
Possible use	1
Used as available	2
Preferred habitat	3

Predicitive Bat Habitat Model - Weighting the Models by Theme

8a **Model Scores and Weights by Theme**

Theme	Code	Model Weight (w^m)	Type Score & Weight (tsi/w^c)	Distance Score & Weight (dsi/w^c)	Type Effect Weight (wte)
Water Sources	WET	2	0.1(0-3)	0.9(0-3)	0.7
Landcover (habitat)	VEG	1.5	0.5(0-3)	0.5(0-3)	–
Geology (caves, crevices)	GEO	1.5	0.1(0-3)	0.9(0-3)	0.7
Elevation (temp)	ELV	1	0-3	–	–
Slope (cliffs)	CLF	1	–	0-3	0.7
Aspect (thermal heating)	ASP	1	0-3	–	–

Model Weight (w^m)

No.	Description	Model Weight (w^m)
1	not applicable	0
2		0.5
3		1
4		1.5
5	very important	2

Predicitive Bat Habitat Model - Final Habitat Suitability Score

9a **Summation of all model formulas**

Theme	Code	Importance to bats	GIS Dataset	Formula
Water Sources	WET	drinking; foraging	NHD, LUWRU	$WET = w^{m} * smi^{WET} * [w^{c}(tsi^{WET}) + w^{c}(dsi^{WET}) + w^{te}(tsi^{nearest}-3)]$
Landcover	VEG	roosting; foraging	SWReGAP	$VEG = w^{m} * [w^{c}(tsi^{VEG-ROOST}) + w^{c}(tsi^{VEG-FORAGE})]$
Geology	GEO	roosting	SWReGAP	$GEO = w^{m} * smi^{GEO} * [w^{c}(tsi^{GEO}) + w^{c}(dsi^{GEO}) + w^{te}(tsi^{nearest}-3)]$
Elevation	ELV	temperature	30m DEM	$ELV = w^{m} * (tsi^{ELV})$
Slope	CLF	cliffs; roosting	30m DEM	$CLF = w^{m} * (smi^{CLF} * dsi^{CLF})$
Aspect	ASP	thermal heating	30m DEM	$ASP = w^{m} * (tsi^{ASP})$

9b **Final Score:** WET + VEG + GEO + ELV + CLF + ASP

Study to determine proper intra-model weights (w^c) for models WET and GEO themes.

Purpose: To determine the proper intra-model weights (w^c) neccessary to properly score cells which are calculated using a distance score (dsi).

Description: Although the examples below refer specifically to the Water Source (WET) model, the results of this study are equally applicable to the GEO model that also requires that type (tsi) and distance (dsi) scores be accounted for in calculating the final value of a cell for bats. In this example, the 7x7 matrices below show the spatial distribution of final scores under the conditions given in the rows and columns. The center, colored cell represents a water source whose type score is determined by the matrix's column heading (tsi = 1 thru 3). Surrounding cells are not water and therefore have a water type score of zero (tsi=0). Distance scores are determined by a cells distance from the matrix's center, or in this case the water. Center cells are water and have a dsi of 3. Cells immediately adjacent to water also receive a dsi of 3. Cells 2 steps from water receive a dsi of 2. Cells 3 steps from water receive a score of 1. Cells any farther than three steps would receive a dsi value of 0 and would drop out of the equation, so are not calucalted. Each matrix is produced using the dsi and tsi rules stated above combined with the algorithm listed at the end of each row.

tsi = 3							tsi = 2							tsi=1						
0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
0.5	1.0	1.0	1.0	1.0	1.0	0.5	0.5	1.0	1.0	1.0	1.0	1.0	0.5	0.5	1.0	1.0	1.0	1.0	1.0	0.5
0.5	1.0	1.5	1.5	1.5	1.0	0.5	0.5	1.0	1.5	1.5	1.5	1.0	0.5	0.5	1.0	1.5	1.5	1.5	1.0	0.5
0.5	1.0	1.5	3.0	1.5	1.0	0.5	0.5	1.0	1.5	2.5	1.5	1.0	0.5	0.5	1.0	1.5	2.0	1.5	1.0	0.5
0.5	1.0	1.5	1.5	1.5	1.0	0.5	0.5	1.0	1.5	1.5	1.5	1.0	0.5	0.5	1.0	1.5	1.5	1.5	1.0	0.5
0.5	1.0	1.0	1.0	1.0	1.0	0.5	0.5	1.0	1.0	1.0	1.0	1.0	0.5	0.5	1.0	1.0	1.0	1.0	1.0	0.5
0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
0.3	0.6	0.6	0.6	0.6	0.6	0.3	0.3	0.6	0.6	0.6	0.6	0.6	0.3	0.3	0.6	0.6	0.6	0.6	0.6	0.3
0.3	0.6	0.9	0.9	0.9	0.6	0.3	0.3	0.6	0.9	0.9	0.9	0.6	0.3	0.3	0.6	0.9	0.9	0.9	0.6	0.3
0.3	0.6	0.9	3.0	0.9	0.6	0.3	0.3	0.6	0.9	2.3	0.9	0.6	0.3	0.3	0.6	0.9	1.6	0.9	0.6	0.3
0.3	0.6	0.9	0.9	0.9	0.6	0.3	0.3	0.6	0.9	0.9	0.9	0.6	0.3	0.3	0.6	0.9	0.9	0.9	0.6	0.3
0.3	0.6	0.6	0.6	0.6	0.6	0.3	0.3	0.6	0.6	0.6	0.6	0.6	0.3	0.3	0.6	0.6	0.6	0.6	0.6	0.3
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
0.7	1.4	1.4	1.4	1.4	1.4	0.7	0.7	1.4	1.4	1.4	1.4	1.4	0.7	0.7	1.4	1.4	1.4	1.4	1.4	0.7
0.7	1.4	2.1	2.1	2.1	1.4	0.7	0.7	1.4	2.1	2.1	2.1	1.4	0.7	0.7	1.4	2.1	2.1	2.1	1.4	0.7
0.7	1.4	2.1	3.0	2.1	1.4	0.7	0.7	1.4	2.1	2.7	2.1	1.4	0.7	0.7	1.4	2.1	2.4	2.1	1.4	0.7
0.7	1.4	2.1	2.1	2.1	1.4	0.7	0.7	1.4	2.1	2.1	2.1	1.4	0.7	0.7	1.4	2.1	2.1	2.1	1.4	0.7
0.7	1.4	1.4	1.4	1.4	1.4	0.7	0.7	1.4	1.4	1.4	1.4	1.4	0.7	0.7	1.4	1.4	1.4	1.4	1.4	0.7
0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.7	1.4	1.4	1.4	1.4	1.4	0.7	0.4	1.1	1.1	1.1	1.1	1.1	0.4	0.1	0.8	0.8	0.8	0.8	0.8	0.1
0.7	1.4	2.1	2.1	2.1	1.4	0.7	0.4	1.1	1.8	1.8	1.8	1.1	0.4	0.1	0.8	1.5	1.5	1.5	0.8	0.1
0.7	1.4	2.1	3.0	2.1	1.4	0.7	0.4	1.1	1.8	2.7	1.8	1.1	0.4	0.1	0.8	1.5	2.4	1.5	0.8	0.1
0.7	1.4	2.1	2.1	2.1	1.4	0.7	0.4	1.1	1.8	1.8	1.8	1.1	0.4	0.1	0.8	1.5	1.5	1.5	0.8	0.1
0.7	1.4	1.4	1.4	1.4	1.4	0.7	0.4	1.1	1.1	1.1	1.1	1.1	0.4	0.1	0.8	0.8	0.8	0.8	0.8	0.1
0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Equal Weight Algorithm

0.5(tsi)+0.5(dsi)

Problems: *Poor water (tsi=1) scores higher than a cell immediately next to tsi=2 water (2.0 vs 1.5)*

TSI Weighted Algorithm

0.7(tsi)+0.3(dsi)

Problems: *Scores drop precipitously with distance. Even when dsi=3, but tsi=0 cell score drops by up to 70%*

DSI Weighted Algorithm

0.3(tsi)+0.7(dsi)

Problems: *Scores behave closer to expected, but still too much drop in score just because type score changes.*

The additional, overall shared problem with these 3 algorithms is that cell scores surrounding a water source do not reflect its type score. In other words, when the cell is not water (tsi=0) then its score is only affected by its distance from, not the quality of the nearest water source.

Score	Definition
0 =	Avoided, not used
1 =	Possible use
2 =	Used as available
3 =	Preferred

DSI Weighted + Type Effect Algorithm

$[0.3(tsi)+0.7(dsi)]+0.3(tsi^{nearest}-3)$

This is one solution to the problem, but it requires another computed score layer - nearest neighbor tsi. Each cell in the study area (Utah) 20 km from a water source would need to obtain the type score of the nearest water source. In this way both the distance and the type/quality of the nearest watersource help determine the score of cells nearby, but not classified as water. The same strategy used here for the water layer would be used for the other two roost layers (GEO and CLF).

See tables on next page.

Fine Tuning: Effect of Changing Dsi and Type Effect Weights

Type Effect Type Effect Type Effect Type Effect Type Effect Type Effect Type Effect

weight =0.7

dsi wt	dsi	tsi		
		3	2	1
0.6	0n	3.0	1.9	0.8
	3	1.8	1.1	0.4
	2	1.2	0.5	0.0
	1	0.6	-0.1	-0.6
0.7	On	3.0	2.0	1.2
	3	2.1	1.4	0.9
	2	1.4	0.7	0.2
	1	0.7	0.0	-0.5
0.8	On	3.0	2.1	1.4
	3	2.4	1.7	1.2
	2	1.6	0.9	0.4
	1	0.8	0.1	-0.4
0.9	On	3.0	2.2	1.6
	3	2.7	2.0	1.5
	2	1.8	1.1	0.6
	1	0.9	0.2	-0.3

weight =0.6

dsi wt	dsi	tsi		
		3	2	1
0.6	0n	3.0	2.0	1.0
	3	1.8	1.2	0.6
	2	1.2	0.6	0.0
	1	0.6	0.0	-0.6
0.7	On	3.0	2.1	1.2
	3	2.1	1.5	0.9
	2	1.4	0.8	0.2
	1	0.7	0.1	-0.5
0.8	On	3.0	2.2	1.4
	3	2.4	1.8	1.2
	2	1.6	1.0	0.4
	1	0.8	0.2	-0.4
0.9	On	3.0	2.3	1.6
	3	2.7	2.1	1.5
	2	1.8	1.2	0.6
	1	0.9	0.3	-0.3

weight =0.5

dsi wt	dsi	tsi		
		3	2	1
0.6	0n	3.0	2.1	1.2
	3	1.8	1.3	0.8
	2	1.2	0.7	0.2
	1	0.6	0.1	-0.4
0.7	On	3.0	2.2	1.4
	3	2.1	1.6	1.1
	2	1.4	0.9	0.4
	1	0.7	0.2	-0.3
0.8	On	3.0	2.3	1.6
	3	2.4	1.9	1.4
	2	1.6	1.1	0.6
	1	0.8	0.3	-0.2
0.9	On	3.0	2.4	1.8
	3	2.7	2.2	1.7
	2	1.8	1.3	0.8
	1	0.9	0.4	-0.1

weight =0.4

dsi wt	dsi	tsi		
		3	2	1
0.6	0n	3.0	2.2	1.4
	3	1.8	1.4	1.0
	2	1.2	0.8	0.4
	1	0.6	0.2	-0.2
0.7	On	3.0	2.3	1.6
	3	2.1	1.7	1.3
	2	1.4	1.0	0.6
	1	0.7	0.3	-0.1
0.8	On	3.0	2.4	1.8
	3	2.4	2.0	1.6
	2	1.6	1.2	0.8
	1	0.8	0.4	0.0
0.9	On	3.0	2.5	2.0
	3	2.7	2.3	1.9
	2	1.8	1.4	1.0
	1	0.9	0.5	0.1

weight =0.3

dsi wt	dsi	tsi		
		3	2	1
0.6	0n	3.0	2.3	1.6
	3	1.8	1.5	1.2
	2	1.2	0.9	0.6
	1	0.6	0.3	0.0
0.7	On	3.0	2.4	1.8
	3	2.1	1.8	1.5
	2	1.4	1.1	0.8
	1	0.7	0.4	0.1
0.8	On	3.0	2.5	2.0
	3	2.4	2.1	1.8
	2	1.6	1.3	1.0
	1	0.8	0.5	0.2
0.9	On	3.0	2.6	2.2
	3	2.7	2.4	2.1
	2	1.8	1.5	1.2
	1	0.9	0.6	0.3

weight =0.2

dsi wt	dsi	tsi		
		3	2	1
0.6	0n	3.0	2.4	1.8
	3	1.8	1.6	1.4
	2	1.2	1.0	0.8
	1	0.6	0.4	0.2
0.7	On	3.0	2.5	2.0
	3	2.1	1.9	1.7
	2	1.4	1.2	1.0
	1	0.7	0.5	0.3
0.8	On	3.0	2.6	2.2
	3	2.4	2.2	2.0
	2	1.6	1.4	1.2
	1	0.8	0.6	0.4
0.9	On	3.0	2.7	2.4
	3	2.7	2.5	2.3
	2	1.8	1.6	1.4
	1	0.9	0.7	0.5

weight =0.1

dsi wt	dsi	tsi		
		3	2	1
0.6	0n	3.0	2.5	2.0
	3	1.8	1.7	1.6
	2	1.2	1.1	1.0
	1	0.6	0.5	0.4
0.7	On	3.0	2.6	2.2
	3	2.1	2.0	1.9
	2	1.4	1.3	1.2
	1	0.7	0.6	0.5
0.8	On	3.0	2.7	2.4
	3	2.4	2.3	2.2
	2	1.6	1.5	1.4
	1	0.8	0.7	0.6
0.9	On	3.0	2.8	2.6
	3	2.7	2.6	2.5
	2	1.8	1.7	1.6
	1	0.9	0.8	0.7

Comment: Type Effect weights of 0.6 & 0.7 seems to provide the best distribution for scores across tsi's.

Comment: Type Effect weights of 0.4 & 0.5 provide fair score declines with a decrease in water type score quality.

Comment: Type Effect weight = 0.3, provides moderate score decline with decrease in tsi. (ex. Water source final score with tsi=1 is half of that generated with tsi=3.

Comment: Type Effect weight = 0.2, provides relatively poor score decline with decrease in tsi. (ex. Water source with tsi=1 is not much worse than tsi=3 at any distance.

Comment: Same as Type Effect Score = 0.2

Comment: Tsi:dsi ratios of 0.2:0.8 and 0.1:0.9 provide a good relationship between the final scores for the dsi scores 'On' and '3'. Given their close proximity (are water themselves or are immediately adjacent to water), they should be close to equal in score. Scores caluclated as negative should be reset to zero.

FINAL ANALYSIS

Highlighted in yellow is the best combination of intra-model and type effect weights. The intra-model weights of dsi:0.9/tsi:0.1 and the type affect weight score of 0.7 provide for the most realistic distribution of final scores as cells increase in distance from the water source. Note cells either 'On' the water source or those still within the most optimal distance (ie. very close) get very similar scores. Checking across water types the relationships also maintain many realistic relationships, albeit if only based on our best assumptions of bat behavior. For example, the algorithm results (represented in yellow) indicate that cells near a water source scoring 3, should maintain a higher value than a cell with a clas 2 water source in it. Similarly, cells immediately adjacent to a possible water source would score higher than a cell 10-20 km from a class 3 water source.

Bat Habitat Suitability Analysis for Utah -Draft-

Metadata also available as

Metadata:

Identification_Information:
Citation:
Citation_Information:
Title: Bat Habitat Suitability Analysis for Utah -Draft-
Edition: ver. 2/2/07
Description:
Abstract:
This shows the result of the Bat Habitat Suitability Model for Utah.
Purpose:
Draft Comments about the suitability process:

This plan applies to all 18 bat species within the State of Utah. The goal of the analysis was to qualify suitable bat habitat within the State of Utah.

Six main habitat preferences were compared; water, vegetation, bedrock, elevation, aspect and cliffs; their sources, frequency and quality. Within each of those six categories, multiple inputs were compiled to create the six layers.

With a lengthy analysis routine and the expectation that team members would like the ability to modify in model values, ModelBuilder was used to build and save geoprocessing routines. ModelBuilder allows for some automation of tasks and for specifying the order in which individual tasks are run.

A weighted overlay technique was used to apply a common measurement scale of values to create an integrated analysis. Inputs were weighted according to values

set by the UBCC working group. See modelexpertdata.xls.

Supplemental_Information:

By using "final.lyr" to display the data, you can see the distribution by one standard deviation. Result values are 0 - 15. Where 0 indicates least suitable habitat, 15 indicates most suitable. These results are based on break values suggested and reviewed by the UBCC, data layers already in existence, and model tools from ESRI, Spatial Analyst.

Time_Period_of_Content:

Currentness_Reference: 2/2/07 v.1.1

Status:

Progress: In work

Use_Constraints: DRAFT

Point_of_Contact:

Contact_Information:

Contact_Person_Primary:

Contact_Person: Gen Green

Contact_Organization: The Nature Conservancy

Contact_Position: GIS Analyst

Contact_Voice_Telephone: 801.238.2322

Contact_Electronic_Mail_Address: ggreen@tnc.org

Data_Set_Credit:

Gen Green, Adam Kozlowski, Utah Bat Conservation Cooperative (UBCC) and its partners.

Native_Data_Set_Environment: ESRI GRID 9.2

Data_Quality_Information:

Lineage:

Source_Information:

Source_Contribution:

Data Sources: Water: National Hydrography Dataset, high resolution, 1:24,000; U.S Geological Survey, 2006. Problems with streams being coded as perennial for the following quads, Salt Mountain, Soldiers Pass, Terra. For this study, these were recoded as "Intermittent". Also included in the water layer were parcels identified as "WATER" and "RIP" (non-agricultural wetland or other riparian type) classes from Water Related Land-Use data; Utah Division of Water Resources, Dec, 2006.

Vegetation & Outcrop: National Gap Analysis Program (SWReGAP), U.S. Geological Survey, 2004 and National Land Cover Data (NLCD), Multi-Resolution Land Characteristics Consortium, 2001. Where SWReGAP = recently burned, recently chained or recently logged, 2001 NLCD data was

substituted. For calculations see: NLCD_to_ReGAP.xls

Elevation, Aspect & Cliffs: 30 meter digital elevation model; U.S. Geological Survey.

Process_Step:

Process_Description:

Model considerations: Where NODATA represents an unknown quality; a value of 0 indicates a known value - NO presence in that cell. So, for areas where we know that a feature does not exist the value of 0 was assigned.

To extend the area of significance around preferred features (eg water) an additional calculation, the nearest type effect, was assigned to cells with a value of 0. The calculation added a small value to each 0 cell, based on its proximity to the preferred features.

Cliffs would be far better represented by a 10 meter rather than a 30 meter DEM. Intermittent streams (from NHD, High Res) were excluded from the distance to water calculation.

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:

Geodetic_Model:

Horizontal_Datum_Name: North American Datum of 1983

Distribution_Information:

Resource_Description: Not for public distribution at this time. gg/2/2/07

Metadata_Reference_Information:

Metadata_Date: 20070202

Metadata_Contact:

Contact_Information:

Contact_Person_Primary:

Contact_Person: Gen Green

Contact_Organization: The Nature Conservancy

Contact_Position: GIS Analyst